AMERICAN UNIVERSITY OF BEIRUT

NATURAL GAS CONSUMPTION, ECONOMIC GROWTH AND CARBON EMISSIONS: EVIDENCE FROM PANEL DATA FOR MENA REGION

by
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AN ABSTRACT OF THE THESIS OF

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Energy in general is an important component in economic growth. Specifically, natural gas plays a key role for economic development. Thus, several studies have investigated the link between natural gas consumption (NGC), economic growth (GDP) and carbon dioxide (CO_2) emissions. This paper employs the panel unit root tests, panel cointegration methods and panel causality test to examine the direction of causality between NGC, GDP and CO_2 emissions for 10 MENA countries covering the annual period 1980-2011. The finding of this study shows that there is no causal relationship between any of the variables in the short run. However, in the long run, there is a unidirectional causality running from NGC and CO_2 emissions to GDP. Besides, to deal with heterogeneity in different economies and with endogeneity bias in the regressors, this study uses both the FMOLS and DOLS estimation techniques to confirm the long run relationship between the relevant variables.

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To My

Beloved Family

CHAPTER I

INTRODUCTION

As the world struggles today to get out of the financial crisis and economic slowdown, economies are now in the process of looking for new strategies to increase their growth and prosperity levels. Due to increasing demand on energy sources for residential, industrial, electricity and power generation purposes, the energy sector became not only a vital component of the economic output for both importers and exporters, but also a very powerful political and economical tool.

On the other hand, energy is considered the major cause of greenhouse emissions. Among the greenhouse gases, carbon dioxide, the dominant contributor to the greenhouse effect, is responsible for more than 60% of the greenhouse effect[1]. Our exorbitant combustion of fossil fuels produces high levels of CO_2 that have been one of the main increasing environmental threats in the last few decades. The adverse impacts of global warming and climate change on the environment have been assessed intensively by different academics, practitioners, and worldwide organizations, such as the United Nations. Several economical and environmental actions were taken by governments and organizations to face the extensive emission of greenhouse gases and its environmental cost. The last decade has produced a series of troubling records in the average global temperature. According to the United Nations Intergovernmental Panel on Climate Change (IPCC), the average temperature is expected to rise by 1-5°C during the coming century. Although numbers can seem to be very small, they can trigger significant climate change. This represents a backward step in our battle against global

[1] UN. *Framework Convention on Climate Change*. United Nations; available from: http://unfccc.com; Internet; accessed 20 March 2014.

warming. As a result, in order to keep global warming below 2ºC[2], carbon dioxide emissions should decrease by 60-80% before 2050. In conclusion, a shift towards less polluting energy resources should be observed immediately to prevent "tipping points". The growing concerns about the fossil fuels' carbon and greenhouse emissions have led several economies to diversify their energy sources, and hence increase the usage of other less harmful sources of energy.

Despite being by itself a fossil fuel, natural gas, which is not a by-product of oil is one of the key players in the energy world today. Although natural gas has been used as an energy source long time ago, it only gained prominence over other sources in the past few years. The gas industry has witnessed a significant rate of development since the early 90s due to the growing attention on environmental issues as a main international matter. Recently, it has achieved a greater weight in the world energy mix. For example, in 2009, the world consumed roughly 104 tcf of natural gas, which represented about 24% of the universe primary[3] energy demand[4]. The study of natural gas increased for several reasons. First, natural gas has many uses as a commodity domestically and is seen as an indispensable input for many industries around the world. Second, it is considered to be more abundant and a widespread resource in terms of availability than its hydrocarbon rivals. Natural gas is found in all continents; it is recently found in Europe. Third, the geological conditions for gas exploration are much

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[2] The Climate Institute; available from http://www.climate.org; Internet; accessed 5 April, 2014.

[3] Bhattacharyaa (2011) said "the term primary energy is used to designate an energy source that is extracted from a stock of natural resources or captured from a flow of resources and that has not undergone any transformation or conversion other than separation and cleaning".

[4] Ratner, M. (2010). "Global natural gas: A growing resource". *Congressional Research* R41542.

less severe than other fossil fuels. Unlike oil, gas does not need huge depth limits to be found. Besides, natural gas is believed to be an environmental friendly fuel when compared to other hydrocarbons in terms of carbon dioxide emissions. It is said to be the lowest carbon releasing fossil fuel when burned. For instance, natural gas releases about 56.1 tCO_2 per TJ, which is much less than emissions from coal (73.3 tCO_2) and those from oil (94.6 tCO_2). In fact, natural gas produces 30% less carbon dioxide compared to oil and almost 70% less compared to coal for an equivalent amount of energy[5]. Its combustion also generates about two thirds less carbon dioxide than coal and one quarter less than oil when consumed in a typical electrical power plant[6]. Moreover, natural gas combustion releases less ash particles, carbon monoxide (CO), sulfur dioxide (SO_2), and nitrogen oxide (NO and NO_2) than its fossil fuel rivals. Ratner (2010) in his report "Global Natural Gas: A Growing Resource" described natural gas as "one of the fuels included in a clean energy standard, particularly as replacement for coal-fired electric power generation". All in all, being inexpensive, clean competitively to other fossil fuels, highly efficient and operationally flexible, natural gas is universally considered as a potential bridge fuel to lower carbon economy.

The International Energy Agency (IEA) reports that 80% of emissions from the energy sector that were planned for 2020 have already been reached and 40% of CO_2 emissions from OECD. Thus, the threat of climate change, the international goal of curbing the rise in the global temperature, and the search for low carbon fuel all strengthen the position of natural gas in both developed and developing economies.

The switch of several countries to less expensive and cleaner energy resources

[5] Bhattacharyya, S. (2011). *Energy economics: Concepts, issues, markets and governance*. London, England: Springer.

[6] Ratner 2010, R41543.

definitely raises the question on the role, consumption and standing of natural gas. It also questions the effects of such energy paradigm on economies' output outlook and growth. Economists and policy makers are interested in assessing the effects of energy policies that promote natural gas conservation and efficiency on economic growth.

Despite the fact that the empirical literature examining the causality relationship between energy consumption and economic growth is quite abundant, empirical studies on the link between natural gas consumption and income are rather limited in the energy economics field. Kraft and Kraft (1978) presented a first case study in the energy economics literature analyzing the causal relationship between energy and GNP in the US. Based on their analysis they found evidence for unidirectional causality running from GNP to energy use. Subsequently, a large number of studies in this area employed diverse methodologies to test such causality; their methods varied in terms of unit root testing, cointegration applications, estimation techniques and causality procedures using descriptive time series data. It is yet believed that a mutual consensus on the direction of causality between energy consumption and GDP was still deemed unfounded[7].

In my thesis, I will examine the relationship between economic growth, carbon emissions, and natural gas consumption for a panel of 10 countries in the Middle East and North Africa (MENA) Region over the period ranging from 1980-2011. Selected countries are Algeria, Bahrain, Egypt, Morocco, Jordan, Oman, Saudi Arabia, Turkey, Tunisia, and United Arab Emirates. The choice of the Middle East and North Africa Region for this case study is motivated by different factors. First, the MENA region has experienced a big boom in its natural gas consumption and carbon emissions in recent

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[7] Payne, J.E. (2010). "Survey of the international evidence on the causal relationship between energy consumption and growth". *Journal of Economic Studies* 37(1): 53-95.

years. Second, there are very few studies that extensively and exclusively examine the energy consumption-economic growth or natural gas consumption-economic growth nexus for the MENA region. Furthermore, countries of the Middle East and North Africa hold about 45% of the world proven gas resources, which is a significant number.

The paper will be organized as follows: The second chapter provides a brief literature review on the causal relationship between energy consumption and economic growth or natural gas consumption and economic growth. Chapter III presents a brief overview of natural gas industry of the countries in the sample and describes the data analyzed. Chapter IV explains methodology used in testing and reports the empirical results. Finally the fifth chapter draws conclusions.

We find based on our panel analysis that there is no causal relationship between any of the variables in the short run. However, in the long run, there is a unidirectional causality running from NGC and CO_2 emissions to GDP.

CHAPTER II

LITERATURE REVIEW

The energy consumption-growth nexus or in our case the link between natural gas consumption and growth is commonly described and explained by the following four hypotheses: growth hypothesis, conservation hypothesis, feedback hypothesis and neutrality hypothesis.

First, the growth hypothesis postulates that energy consumption is an indispensable component in growth given that energy is a direct input in the production process and also, energy acts as an indirect factor that complements both labor and capital. If the causality runs from energy/gas consumption to economic growth, then the growth hypothesis is valid. In this case, energy conservation policies such as the upgrading in energy/gas efficiency and demand management policies designed to reduce energy/gas use lower economic income implying that the economy is energy/gas dependent.

Second, the conservation hypothesis implies that energy/gas use is dictated by the economic development. Unidirectional causality from economic income to energy/gas consumption lends support for the conservative hypothesis. Under this scenario, energy saving policies which reduce energy/gas utilization may have little adverse or no impact on economic growth.

Third, the feedback hypothesis suggests that energy/gas consumption and economic growth affect each other. The feedback hypothesis is confirmed by the existence of bi-directional causality between energy/gas use and economic income. The implication of the bi-directional relationship is that energy/gas use and gross domestic product (GDP) are interdependent and serve as complements. This complementary relationship opens the following possibility: an increase in energy/gas use will stimulate economic growth, and an increase in economic income will motivate the utilization of energy/gas.

Finally, the neutrality hypothesis states that energy/gas consumption is a relatively minor input in the generation of economic growth; it has no significant impact. The absence of causality between energy/gas consumption and economic growth substantiates the neutrality hypothesis. The policy implication of the neutrality hypothesis is that the reduction in energy/gas use through energy conservation policies may not adversely impact GDP.

Starting with the first type, Adjaye (2000) studied the causality relationship between energy consumption and income for India and Indonesia over the period 1973-1995. Applying the technique of Johansen-Juselius cointegration (JJ) and error correction model (ECM) the results for India and Indonesia reported that energy consumption plays its role in affecting income in the short-run. This implies that a decrease in the volume of energy consumption will slow economic growth in case of India and Indonesia. In the same way, Soytas and Sari (2003) examined the impact of energy consumption on economic growth for G-7 countries and emerging markets (excluding China) over the period of 1950-1992. They proved mixed results by using Johansen-Juselius method and vector error-correction model (VECM) analysis. For pattern of Turkey, France, Germany, and Japan, the causality runs from energy consumption to growth. Besides, Farhani and Shahbaz (2013) emphasized the importance of trade factor in the relationship between natural gas consumption, real output, and real gross fixed capital formation in Tunisia over the period of 1980-2010. They used different modern econometric methods involving autoregressive distributed lag model (ARDL) and VECM. Results indicated the existence of long-run relationship among the above mentioned variables. The authors noted the presence of unidirectional Granger causality running from natural gas consumption, real gross fixed capital formation, and trade to real GDP. Furthermore, an augmented form of Granger causality analysis was carried out by Halicioglue (2009) on the basis of time series data for Turkey for the period 1960-2005. The results justified the existence of two forms of long-run relationships between the following variables: carbon dioxide emission, energy consumption, income, and foreign trade. For the first case, carbon emissions are caused by energy use, Turkey's output and trade. For the second case, carbon emissions, energy use and trade lead to economic growth in Turkey. Recently, Mahmoudinia, Amroabadi, Pourdhahabi and Jafari (2013) explored the causal relationship between oil products consumption, electricity consumption, energy price, and economic growth for Iranian economy for the period 1973-2006. Using ARDL bounds testing approach to co-integration, they discovered long run co-integration between economic growth, price, and oil consumption also between economic growth, price, and electricity consumption. Using a model for error correction analysis, the results confirmed that GDP is determined by oil and electricity consumption. Lee and Chang (2008) also found a positive impact of energy use on economic output in the long-run for 16 Asian countries while a heterogeneous panel co-integration and panel error correction model (ECM) were applied taking sample of period 1971-2002. This is an indicative of energy dependent economies in which energy is an impetus for growth, with the implication being that a reduction in the amount of energy available would likely negatively affect income. Adhikari and Chen (2012) explored the long run dynamic causal relationship between GDP and energy use for 80 developing selected countries. Time series data has been used for the period 1990-2009. Applying panel cointegration and panel dynamic ordinary least squares (DOLS), Adhikari and Chen found that in the long run energy use has a positive considerable effect on economic development. Allowing for structural breaks in unit root and co-integration testing, Lee and Chang (2005) studied the relationship between energy use (at both aggregated and disaggregated levels) and GDP for Taiwan for the period of 1954-2003. They revealed a unidirectional causality running from oil, gas, and electricity use to GDP. Thus, waste and deficient in oil, gas, and electricity are detriment for economic growth in Taiwan's economy.

Supporting the second type, Ben Rajab and Farhani (2012) looked at the relationship between the per capita energy consumption, per capita GDP, and per capita carbon dioxide emissions on the basis of panel data for 15 countries in the MENA region for the period 1973-2008. Employing the panel co-integration technique and Granger causality test, growth and carbon dioxide emissions are the long-run causes for energy consumption for all countries. The results indicated that energy conservation policies have no damaging effect on economic growth for this group of countries. Another study was conducted in India using series data for the period 1970-71 to 2004-5. Through the application of variance decomposition analysis of vector autoregression (VAR), Mallick (2009) found that the economic growth drives crude oil consumption. On the basis of time series data for Malaysia for the period 1970-2008 and applying both ARDL and Toda Yamamoto (TY) testing approaches, Lean and Smyth (2010) examined the relationship between electricity use, exports, prices, and GDP using a multivariate model. They found evidence supporting the unidirectional causality from GDP to electricity generation. Lee and Smyth concluded also that export-led and handmaiden theories are not clearly verified, and there is no causal relation between prices and GDP. Additionally, Cifter and Ozun (2007) suggested a wavelet analysis as a semi-parametric model for testing the linkage between electricity consumption and economic growth in emerging economies for the period 1968-2002. The long run findings showed evidence for conservative hypothesis between energy use and growth. In an analysis of both aggregated and disaggregated consumption measures for China during 1963-2005, Yuan, Kang, Zhao, and Hu (2008) used neo-classical aggregate production to test the relationship between energy use and economic output. They utilized Johansen co-integration procedure to expose the presence of long run relationship among output, labor, capital and energy use at both aggregated and disaggregated levels. Applying the dynamic vector error correction model (VECM) and causality tests, they noted that economic growth causes oil, coal, and total energy consumption. Binh (2011) studied the dynamic causal relationship between per capita energy use and per capita GDP in Vietnam during the period 1976-2010. Methods of threshold cointegration and vector error correcting model were applied. Results showed that energy consumption is fundamentally driven by economic development. Shortage of energy means lower economic growth in Vietnam, which seems to be energy dependent. Ahmad, Hamad, Hayat and Luqman (2012) looked at causal link between energy use and GDP in Pakistan using time series data from 1973-2006. The results of ordinary least square (OLS) estimation and Granger causality showed a strong positive unidirectional causality running from income to energy use. Thus, the government of Pakistan can follow saving energy policies that restrict the use of energy for environmental clean development purposes without generating harsh consequences on their economic income. Eddrief-Cherfi and Kourbali (2012) explored the energy use-growth nexus in Algeria. Causal relationship between per capita energy consumption and per capita GDP during 1965-2008 was examined using threshold cointegration and Granger causality. The results suggested a one way causal relationship running from economic growth to energy consumption. Then, the demand for energy in Algeria is driven largely by strong economic growth. Besides, using panel cointegration and panel causality techniques, Lee and Lee (2010) found a unidirectional causality running from GDP and electricity consumption for 25 OECD countries during 1978-2004. Then, their regional agenda should include efficient collaboration and plans to put into action some electricity conservative policies in order to sustain their economic development. On the other hand, Payne (2011) using time series data for the US for the period 1949 to 2006 and employing Toda-Yamamoto (TY) long-run causality test proved that it is the real GDP which leads to demand of natural gas, and it is only petroleum consumption which has a positive influence on growth.

For the third type, Apergis and Payne (2010) confirmed the existence of a long-run equilibrium relationship between natural gas consumption, real GDP, real gross fixed capital formation, and labor force for a panel data of 67 countries during 1992-2005. Using Pedroni's heterogeneous panel co-integration and panel vector error correction modeling techniques, they found a bi-directional causality between natural gas consumption and economic development in both short-run and long-run dynamics. Moreover, using Bootstrap corrected causality test on time series data from G-7 countries for the period 1970-2008, Aslan, Kum and Ocal (2012) concluded that there is a bi-directional relationship between natural gas consumption and economic development for US, Germany, and France. In case of Portugal, employing ARDL and Toda Yamamoto testing approaches, Tang and Tan (2012) revealed the presence of bi-directional causal relationship between electricity use and economic development during the period 1974-2008. As a result, Portugal should invest in the electricity infrastructure and avoid any decline in the electricity demand because it adversely affects the Portugal's economic output. In addition, using a neo-classical production technology function, Ghali and El-Sakka (2004) conducted a study to realize the link between capital, labor, output, and energy use in Canada for the period 1961-1997. The results suggested the presence of long-run movement between capital, labor, output, and energy consumption using Johansen co-integration technique and bi-directional causal relationship between energy use and output through vector error correction model (VECM). On the basis of panel data for 22 OECD countries for the period 1960-2001 and applying co-integration test and vector error correction model (VECM) Lee, Chang, and Chen (2008) explored the relationship between energy consumption and economic growth using an aggregate production function and controlling for capital stock. The findings suggested the existence of strong long-run bi-directional relationship between variables. Thus, the paper indicated the importance of capital stock in examining the relationship between energy use and economic development. Recently, Farhani, Rahman and Shahbaz (2013) investigated the relationship between natural gas consumption and economic output using production function incorporating labor, capital, and exports in case of France. They confirmed the presence of co-integration between the variables and found that economic growth contributes natural gas consumption through ARDL testing method considering sample period of 1997-2010. Applying vector error correction model, their analysis also exposed the bi-directional effect between GDP and natural gas use, exports and GDP, exports and natural gas consumption, exports and capital, capital and energy consumption. Then, the implementation of energy saving policies would have few, if any, adverse effects on GDP growth in case of France. Glasure and Lee (1998) provided a detailed analysis of relationship between energy use and economic development for South Korea and Singapore during 1961-1990. Error correction modeling technique indicated the presence of bi-directional causality between both variables. Belke, Dreger and Haan (2010) investigated energy consumption-growth nexus for 25 OECD countries from

1981 to 2007. Results of the causality test show a bi-directional link between GDP and energy utilization in the long run. Furthermore, Belloumi (2009) examined the long run relationship between per capita energy use and per capita income in Tunisia during 1971-2004. With the aid of vector error correcting model procedure, he found out a bi-directional causality between the two series. Hossain and Saeki (2012) applied panel cointegration and Granger causality tests to examine the electricity demand effect of 76 selected countries over 1960-2008. A bi-directional relationship is found both in short and long runs for high income, middle income, and income global panels of the selected countries. Similarly, Campo and Sarmiento (2013) empirically examined the dynamic connection between GDP and energy utilization for 10 countries in Latin America using time series data from 1971-2007. Panel cointegration and Granger causality tests indicated the presence of bi-directional link between both variables. Moreover, Narayan and Smyth (2009) applied the techniques of panel unit root and co-integration tests to inspect electricity consumption, exports, and GDP of 6 Middle Eastern countries for the period 1974-2002. They found a bi-directional causal relationship between electricity demand and GDP as well as a unidirectional causal relationship running from exports to GDP. In conclusion, electricity saving policy is detrimental to these countries' development.

Developing the last type, Acaravci and Ozturk (2010) explored the dynamic relationship between energy consumption, real output, carbon dioxide emissions, and employment ratio for Turkey over the period 1968-2005. They utilized autoregressive distributed lag (ARDL) bounds co-integration analysis to find evidence of a long-run relationship between the mentioned variables. The error correction based Granger causality model failed to find a causal relationship between per capita carbon dioxide emissions, per capita energy consumption, and per capita real income giving. On the other hand, ECM Granger causality approach revealed that employment ratio adds in per capita real income in short-run dynamics. In conclusion, energy conservative policies are likely to have no adverse effect on real income of Turkey. Bowden and Payne (2008) examined the causal relationship between energy consumption and real economic development using aggregate and sectoral primary energy consumption measures for the United States of America over the period 1949-2006. Applying the Toda and Yamamoto multivariate procedure, the results indicated that the relationship between real GDP and energy consumption is not uniform across different sectors. The authors noted that Granger causality is absent between total and transportation primary energy consumption and real GDP, so transportation primary energy consumption does not affect income whatsoever. Moreover, Yu and Choi (1985) used the notion of Sims and Granger causality for different countries for the period 1950-1976 to examine the link between energy consumption and economic income. The results justified the neutrality of energy use and income for United States, United Kingdom, and Poland. Gocen, Gursoy and Kalyoncu (2013) analyzed the relationship among energy consumption and income in Georgia and Azerbaijan for the period 1995-2009 using Engle Granger cointegration and Granger causality tests. The findings suggest energy consumption and income appear to be neutral with respect to each other. Altinay and Karagol (2004) investigated the link between economic growth and energy use in Turkey during 1950-2000. Zivot Andrews structural break and Hsiao's version of Granger causality tests were used in order to analyze the causal relationship. It is found that these two variables are not related based on detrended data supporting the neutrality hypothesis. Moreover, Karanfil and Jobert (2007) used Granger causality and VAR techniques to detect the causality between GDP and energy consumption on industrial sector and at aggregate level in Turkey over the period 1960-2000. No evidence of causality was found between the two variables both at aggregate and industrial levels.

CHAPTER III

DATA AND DESCRIPTIVE STATISTICS

A. Data Description

The annual data set is a balanced panel of 10 Middle Eastern and North African countries covering the period from 1980 to 2011. The variables used in this case study are natural gas consumption (NGC) measured in cubic feet per capita, economic growth per capita (GDP) measured in constant 2005 US$, and carbon dioxide emissions (CO_2) in metric tons per capita. The 10 MENA countries included in our sample are: Algeria, Bahrain, Egypt, Jordan, Morocco, Oman, Saudi Arabia, Tunisia, Turkey, and the United Arab Emirates. The data are sourced from World Bank Development Indicators (WDI) and US Energy Information Administration (EIA) employed with their natural logarithmic form to reduce heterogeneity.

In our case study, the long run relationship between natural gas consumption, economic growth, and carbon dioxide emissions per capita will be represented by the following equation:

$$LNNGC_{i,t} = \beta_i + \gamma_i \, LNGDP_{i,t} + \eta_i \, LNCO_{2i,t} + \varepsilon_{i,t}$$

where:

LN: denotes the natural logarithmic form of the variables

i and t: denote the country and the time respectively

β_i: denotes the constant country effect

$\varepsilon_{i,t}$: denotes the white noise stochastic error term

γ_i and η_i: proxy as the natural gas consumption elasticity of economic growth and carbon dioxide emissions respectively.

B. Brief Gas Profile: Individual Analysis

1. Algeria

Algeria, which is the largest country in Africa, was considered in 2011 as the world's 49th largest economy in terms of nominal GDP which accounted for 190.709 billion U.S. dollars[8]. Besides, Algeria relies heavily on the energy exports. The energy sector is considered the primary growth engine of the Algerian economy. It accounted for 98% of exports earnings and about 70% of the government budget revenue in 2011[9].

Table 1. Basic Energy Facts in Algeria (2007-2011)

Basic Energy Facts	2007	2008	2009	2010	2011e
Total Energy Consumption (mtoe)	40.83	43.37	46.35	..	..
CO2 emissions, energy-related (MMt)	101.15	106.83	112.19	110.90	..
CO2 intensity, energy-related (tCO2/toe)	..	..	..	..	..
Energy consumption per capita (toe/cap)	1.22	1.28	1.36	..	..
CO2 per capita, energy-related (tCO2/cap)	3.03	3.16	3.28	3.21	..

Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

Algeria is believed to be a main producer of natural gas in Africa. It was the 8th largest producer of natural gas in the whole world according to estimates of 2010. Production in 2011 yielded an estimated 77 bcm[10] (2.4% of the world's total production) of which approximately 68% was exported abroad. However, the level of production of natural gas has decreased since 2005 (88.2 bcm) for several reasons. First, the bulky and

[8] Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

[9] Ibid.

[10] Billion Cubic Meters.

mature fields in Algeria started depleting. Second, new production and infrastructure developments have continually been postponed. Moreover, natural gas accounts for more than half of all of Algeria's total energy consumption (62% for natural gas and 38% for oil).

Consumption of natural gas has increased recently. In 2011, the consumption of natural gas was 27.5 bcm, a 6.5% compared to 2010 (26.2 bcm).

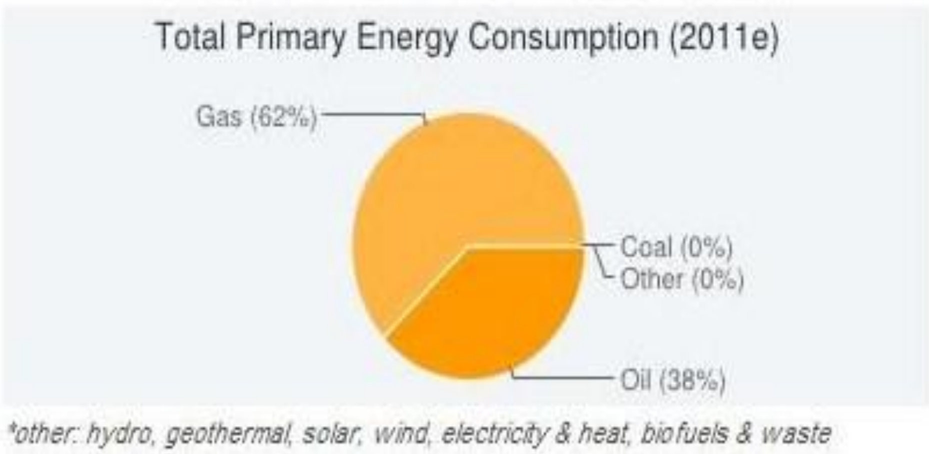

Fig. 1. Total Primary Energy Consumption in Algeria (2011)
Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

Table 2. Basic Gas Facts in Algeria (2007-2011)

Basic Gas Facts	2007	2008	2009	2010	2011e
Gas reserves (bcm)	..	..	4504	4504	4504
Gas production (mcm)	81539	81747	78553	79730	76780
Gas consumption (mcm)	24761	24955	26862	26195	27531
Gas imports (mcm)	-	-	-	-	-
imports pipeline (mcm)	-	-	-	-	-
imports LNG (mcm)	-	-	-	-	-
import dependency (%)*	-	-	-	-	-
Gas exports (mcm)	56814	56792	51979	53895	49476
Technically recoverable shale gas resources (bcm)	..	..	6541.92	..	..

Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

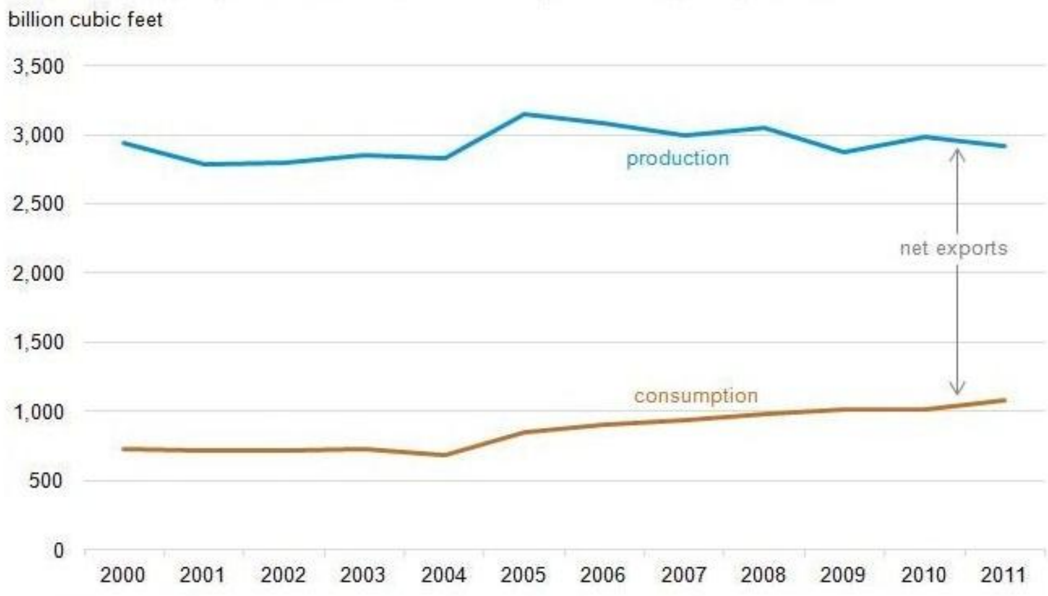

Fig. 2. Dry Natural Gas Production and Consumption (2000-2011)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

On the other hand, as production decreased and consumption increased, natural gas exports started decreasing progressively, yet Algeria is still considered as the primary exporter for Europe. Algeria exports natural gas either through pipelines or on tankers in the form of liquefied natural gas (LNG). It has three transcontinental export gas pipelines (two which transport natural gas to Spain and one which transports natural gas to Italy) as well as three LNG complexes, which are two in Arzew and one in Skikda[11]. Algeria was the first country in the whole world to export LNG in 1964. In 2011, Algeria was the 4th largest supplier of natural gas to Europe (32.8 bcm out of 34.4 bcm) after Russian Federation (140.6 bcm), Norway (92.8 bcm), and Netherlands (50.4 bcm)[12]. In Europe, Italy was the major importer from Algeria getting 44% of its total

[11] US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

[12] BP Statistical Review of World Energy. 2012; available from http://www.bp.com/statisticalreview; Internet; accessed 29 January 2014.

exports (21.3 bcm; 62% of total exports via pipeline and 1.6 bcm; 9 % of total exports via liquefied natural gas tankers) followed by Spain which got 26 % of Algeria's total exports of natural gas in 2011 (9.4 bcm, 27% of total exports; via pipeline and 4 bcm; 23 % of total exports via liquefied natural gas tankers). In addition, Algeria was the 7th largest exporter of liquefied natural gas in the whole world which was estimated to be 5.2% of the world's total LNG exports (31% of its national exports). The main importers of LNG from Algeria are: Spain, Italy, UK and France.

Table 3. Total Exports by Country in Algeria (2007-2011)

By country (in mcm)	2007	2008	2009	2010	2011	%Total Exports 2011
Belgium	387	-	-	-	-	-
Chile	-	-	-	173	-	-
France	7254	7044	7110	6175	5415	10%
Greece	905	985	526	1142	728	1%
Italy	24584	25992	22670	27670	22952	44%
Japan	1327	688	84	-	157	0.3%
Korea	240	446	78	-	-	-
Luxembourg	45	43	-	-	-	-
Mexico	81	-	-	-	-	-
Portugal	1470	2036	1996	1949	1914	4%
Slovenia	361	326	299	347	298	0.6%
Spain	13564	13878	12708	12008	13426	26%
Turkey	4205	4148	4487	3907	4156	8%
United Kingdom	613	287	1763	1051	163	0.3%
United States	2189	-	-	-	-	-
Morocco	587	511	583	623	625	1%
Tunisia	2016	2508	2016	1934	2114	4%
China, People's Rep.	423	167	-	-	-	-
Chinese Taipei	155	77	-	-	-	-
India	545	530	158	-	200	0.4%
Total	60951	59666	54478	56979	52148	100%
%Total Production	75%	73%	69%	71%	68%	

Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

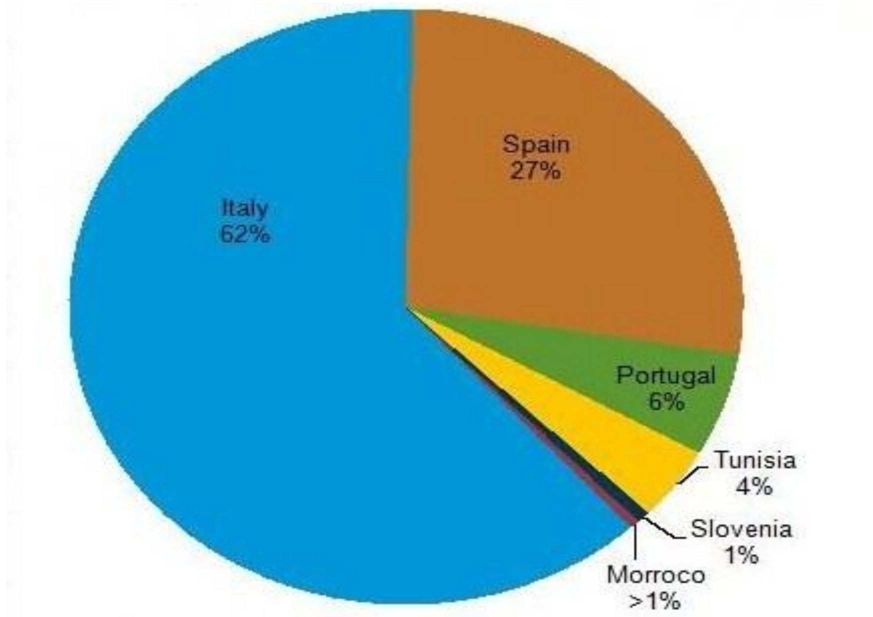

Fig. 3. Algerian Natural Gas Pipline Exports by Final Destination (2011)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

Table 4. Exports of Natural Gas by Transportation Type (2007-2011)

By transport type (in mcm)	2007	2008	2009	2010	2011	%Total 2011
Pipeline exports	35712	39125	33493	38118	35922	69%
LNG exports	25239	20541	20985	18861	16226	31%
Total	60951	59666	54478	56979	52148	100%

Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

Algeria holds a significant natural gas reserves. Algeria's proven reserves[13] are registered at around 4.5 tcm[14] (2.2% of the world's reserves) and the reserve to

[13] Generally taken to be those quantities that geological and engineering information indicates with reasonable certainty can be recovered in the future from known reservoirs under existing economic and operating condition.

[14] Trillion Cubic Meters.

production ratio[15] was 57.7 years at the end of 2011. Despite production, natural gas reserves remained at approximately the same level in the last few years due to the discovery of new reserves. In 2012, Algeria achieved the 10th place in the world for holding large natural gas reserves and achieved the 2nd place in Africa following Nigeria[16]. This goes to the fact that the largest natural gas field found in the eastern area of Algeria is Hassi R'Mel, which was discovered in 1956 and has more than half of Algeria's total proven natural gas reserves. The rest of natural gas reserves come from connected and non-connected fields in the south and southeast regions of Algeria[17].

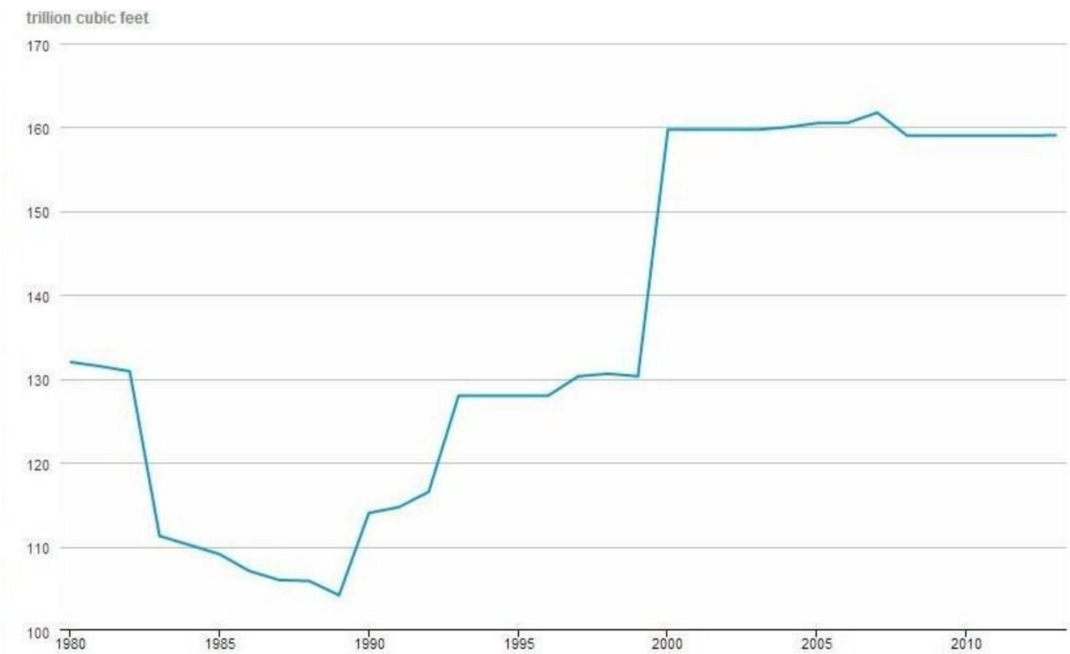

Fig. 4. Algerian Natural Gas Proven Reserves (1980-2011)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

[15] If the reserves remaining at the end of any year are divided by the production in that year the result is the length of time that those remaining reserves would last if production continues at that rate.

[16] Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

[17] BP Statistical Review of World Energy 2012.

2. Bahrain

The oil and natural gas sector is one of the most economic sectors in the Bahrain. Despite the relatively small reserves of natural gas, returns for this sector provided about 25% of GDP and covered approximately 76% of the government expenditure[18].

Production of natural gas is increasing gradually in the last few years, yet Bahrain is considered a small producer of natural gas relative to rest of the world. In fact, it consumes almost all of natural gas produced. In 2011, Bahrain produced 13 Bcm of natural gas which accounted for 0.4% of the world's total production. Bahrain was the 35th producer of natural gas at that time[19].

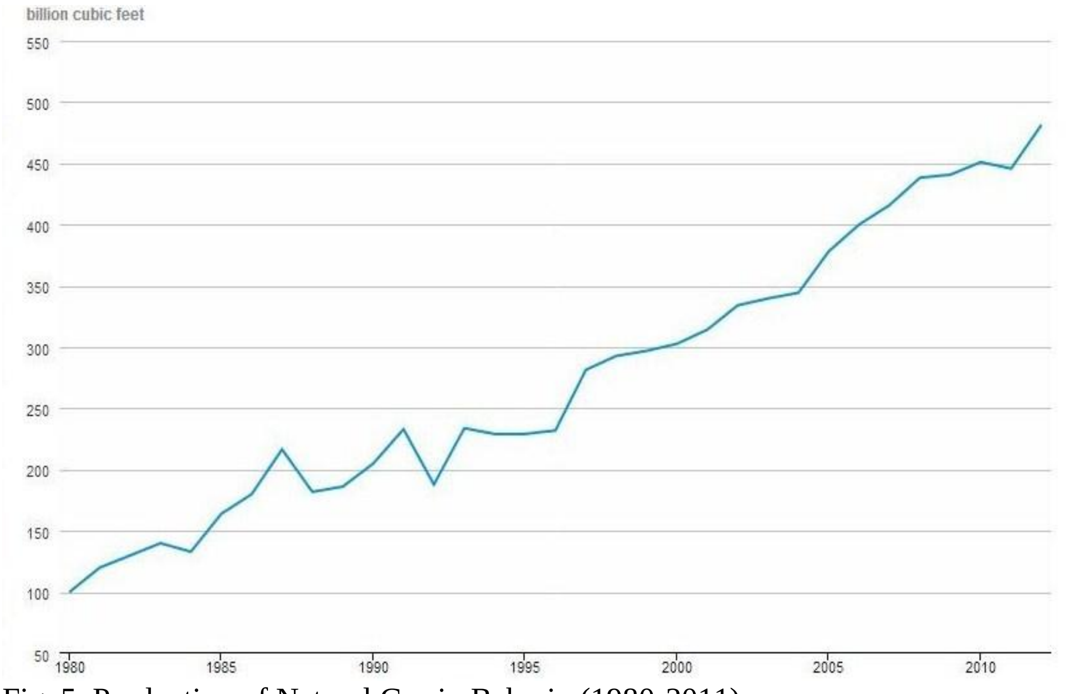

Fig. 5. Production of Natural Gas in Bahrain (1980-2011)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

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[18] *global*EDGE, Michigan State University; available from http://www.globaledge.msu.edu; Internet; accessed 11 February 2014.

[19] US Energy Information Administration 2014.

It is noteworthy to mention that Bahrain consumes more than its production of natural gas. For example, Bahrain consumed 30.4 bcm in 2011 which is much greater than its production of the same year. The domestic demand of natural gas for residential, commercial, and other sectors has increased rapidly since 2000. This highlighted the need of Bahrainis to import natural gas from other sources. Thus, in order to meet its needs, Bahrain started looking for importing natural gas either through pipelines from its neighbor Qatar or via liquefied natural gas terminals especially that it is planning to be an LNG import hub for the northern Gulf[20].

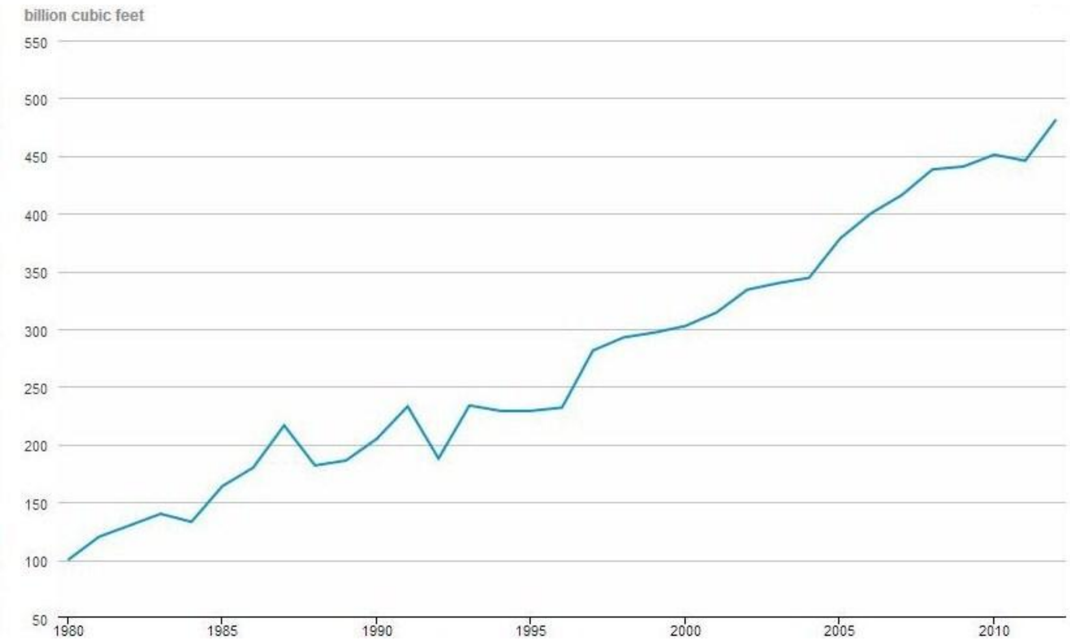

Fig. 6. Consumption of Natural Gas in Bahrain (1980-2011)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

Besides, natural gas reserves are decreasing rapidly as shown in the Figure 7. This significant decrease is due to very high demand of natural gas associated with the

[20] US Energy Information Administration 2014.

presence of very small reserves in return. Bahrain holds about 12.3 Tcf proven reserves since 2002. At the end of 2011, gas reserves were expected to run out in 26.8 years[21] which is considered to be a very short period with respect to other countries.

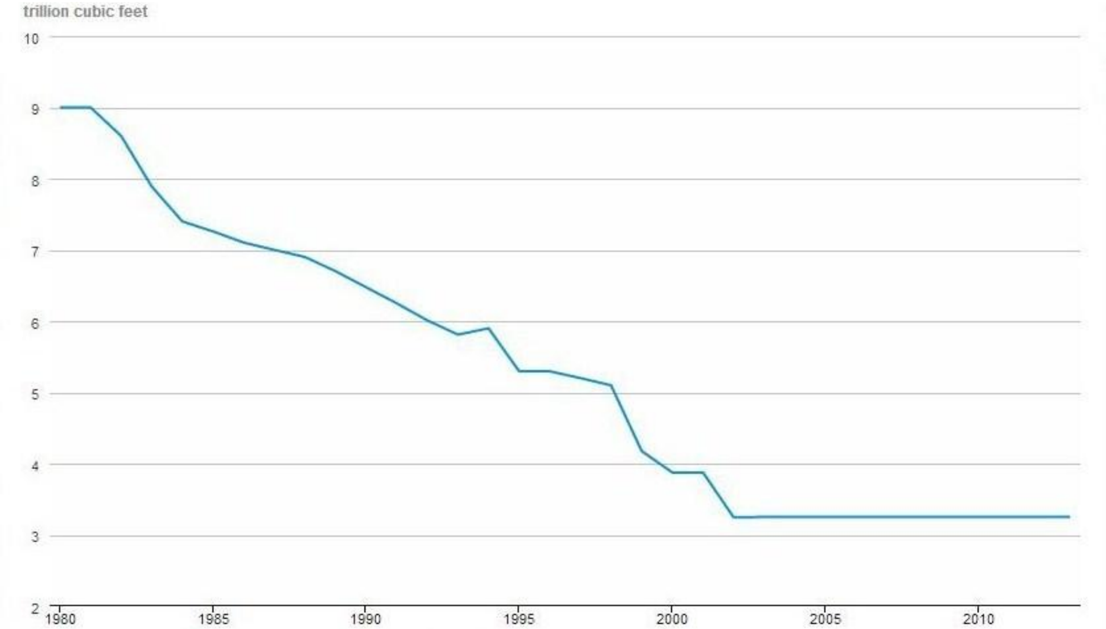

Fig. 7. Bahrain's Natural Gas Proven Reserves (1980-2011)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

3. Egypt

Egypt is the third populous country in Africa (82 million people in 2011) after Nigeria and Ethiopia, and it is the 16th most populated country worldwide. Egypt also recorded the 2nd highest GDP (519 billion in US$) after South Africa according to the World Bank in 2011. It has a well-developed energy sector based on oil and natural gas due to major recent discoveries. For example, in 2010, the total primary energy consumption was 81 mtoe where 40.6 accounted for gas consumption only.

[21] BP Statistical Review of World Energy 2012.

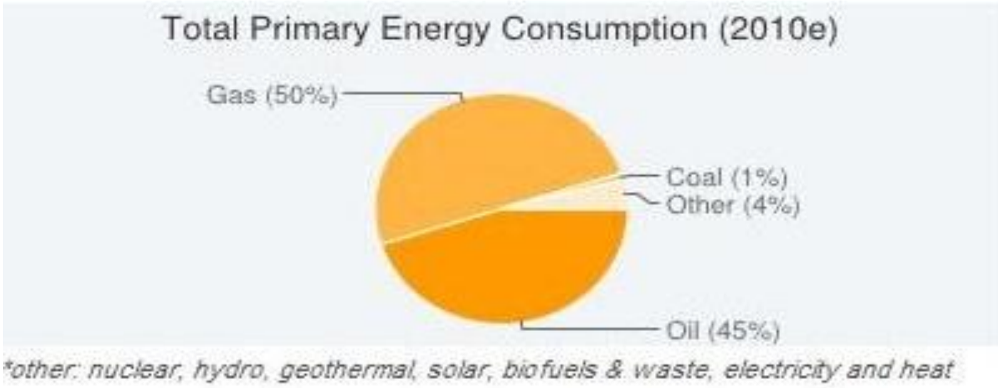

Fig. 8. Total Primary Energy Consumption in Egypt (2010)
Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

Natural gas sector is expanding in a rapid manner, and it is considered one of the main revenue generators in Egypt. The country's natural gas production quadrupled between 1998 and 2009. It jumped from 646 bcf in 2000 to 2.2 tcf in 2010. In 2011, Egypt was the 2nd largest producer of natural gas in Africa after Algeria and the 15th largest producer in the world.

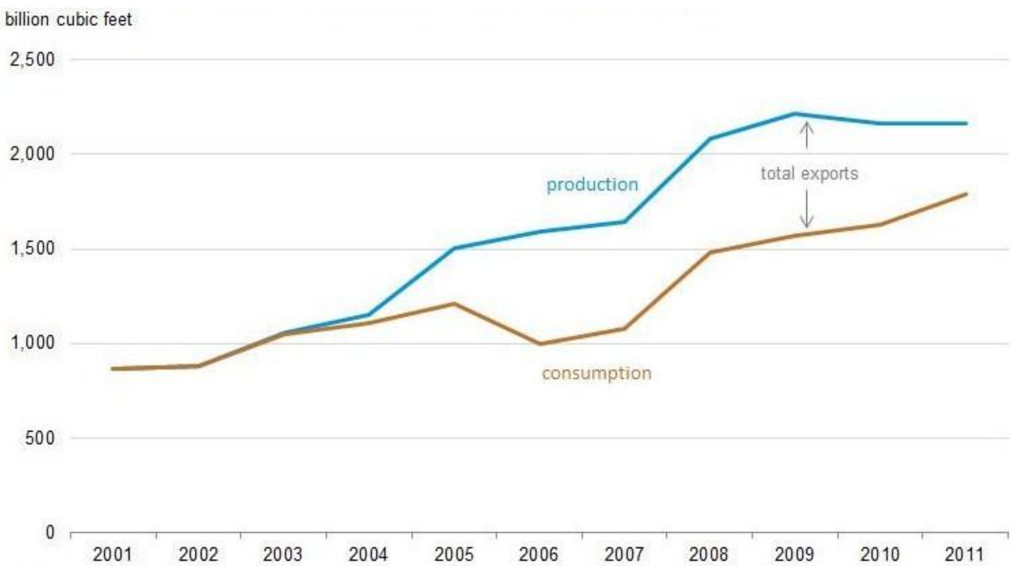

Fig. 9. Dry Natural Gas Production and Consumption in Egypt (2001-2011)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

Egypt produced 61.3 bcm of natural gas which is 0.1% less than the previous year (62.7 bcm), of which 49.6 bcm was consumed and 11.7 bcm exported. In addition, natural gas consumption increased by 10% from 2010 where most of the consumed amount was used for electricity.

Due to high levels of production, Egypt is considered as an important supplier of natural gas to several Mediterranean and European countries such as France, Israel, Spain, Jordan, and others. In 2010, Egypt supplied about 15 bcm of natural gas which accounted for 25% of its production.

Table 5. Exports by Country of Destination in Egypt (2006-2010)

By country of destination (in mcm)	2006	2007	2008	2009	2010	%Total Exports 2010
Belgium	..		84	88	172	1.12%
Canada	..			84		
Chile	..				374	2.44%
France	..	1067	938	1427	665	4.33%
Greece	..			253	46	0.30%
Israel	..		320	1510	2100	13.68%
Japan	..	2278	1777		763	4.97%
Korea	..	1451	2927	312	959	6.25%
Mexico	..	1108	1177	454	83	0.54%
Spain	..	4196	4632	4508	2825	18.41%
Turkey	..				270	1.76%
United Kingdom	..	162		528	115	0.75%
United States	..	3245	1553	4543	2067	13.47%
Argentina	..		100	160		
Brazil	..				90	0.59%
Jordan	..	2744	3149	3579	3165	20.62%
Kuwait	..				450	2.93%
Lebanon	..			50	255	1.66%
Syria	..		140	910	690	4.5%
China	..		250	82		
Chinese Taipei	..	981		73	172	1.12%
India	..	91	240	330	86	0.56%
Total*	16630	17323	17287	18891	15347	100%
%Total Production	30.46%	30.82%	28.71%	29.97%	24.89%	

Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

Jordan is considered the main importer of the Egyptian gas (3.1 bcm; 20.62% of 2010 exports) followed by Spain (2.8 bcm; 18.41% of 2010 exports), Israel (2.1 bcm; 13.68% of 2010 exports) and United States (2 bcm; 13.47% of 2010 exports). The Arab Gas Pipeline is the main transporter of natural gas from Egypt to Lebanon, Israel, Syria, and Jordan.

The slowdown in LNG exports is mainly due to expansion of domestic gas demand. Exports to OECD economies accounted for 10.4 bcm out of which 8.3 bcm are transported through LNG tankers. Egypt mainly supplies natural gas in the liquefied form. For example, in 2010, almost 60% of total natural gas exports were in the form of LNG. Egypt had by the end of 2011 two operational LNG terminals associated with three liquefaction trains.

Table 6. Exports by Transportation Type in Egypt (2006-2010)

By transport type (in mcm)	2006	2007	2008	2009	2010e	%Total 2010
Pipeline exports	..	3064	3289	6049	6210	40.46%
LNG exports	14328	14579	13678	12842	9137	59.54%
Total	14328	17643	16967	18891	15347	
%Total Production	26.25%	31.38%	28.18%	29.97%	24.89%	

Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

Egypt is recognized by its high natural reserves number. For instance, its proven reserves stood at 65 tcf in 2004 up from 55 tcf in 2002 and 45 tcf in 2000. Egypt held 77.3 tcf of proven natural gas reserves in 2011 (3^{rd} highest in Africa after Algeria and Nigeria), which represents about 1.1% of the world's total reserves. The reserve to production ratio at the end of 2011 was 35.7 years. Over 80% of the natural gas reserves are found in the Western Desert, Mediterranean Sea and Nile Delta.

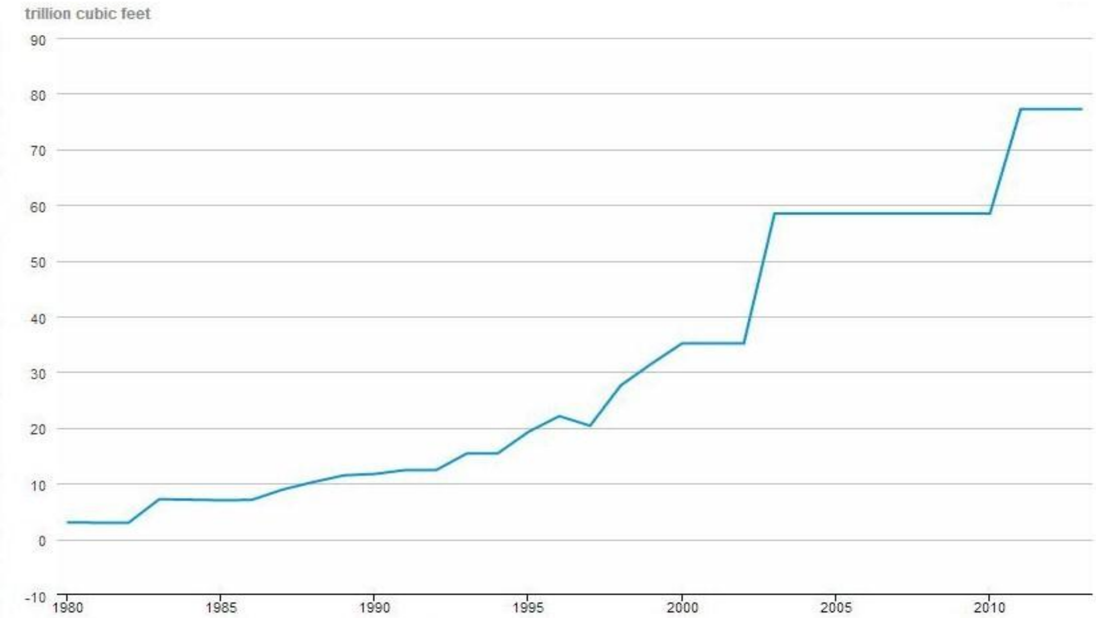

Fig. 10. Proven Natural Gas Reserves in Egypt (1980-2011)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

4. Jordan

Jordan which is located in the north western region of the Arabian Peninsula does not enjoy substantial and diverse energy resources of its own. Unlike its immediate neighbors, Jordan depends heavily on imports of energy resources such as crude oil, petroleum products and natural gas to fulfill its domestic needs. For example, according to the department of statistics, Jordan was only able to produce 3% of its oil and gas demand[22] in 2011. Natural gas is increasingly being demanded to achieve government need especially for electricity generation.

[22] US Energy Information Administration 2014.

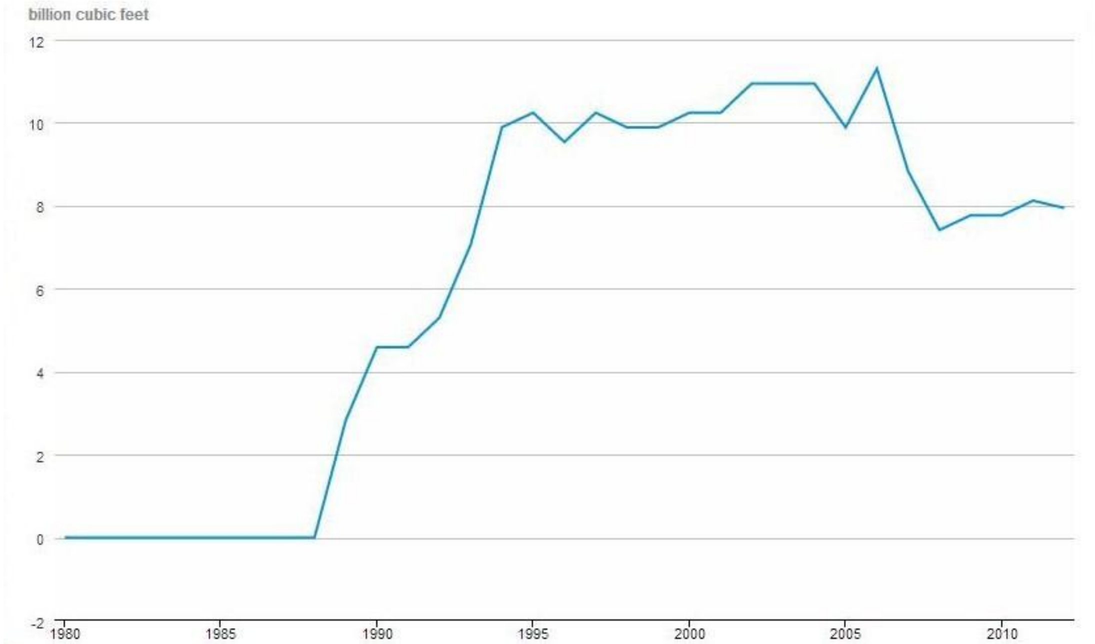

Fig. 11. Natural Gas Production in Jordan (1980-2011)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

Jordan started its own production of natural gas in 1989. Production of natural gas witnessed a dramatic increase from 3 bcf in 1998 to11 bcf in 2006. Jordan has slightly lowered its own production of natural gas to 7 bcf in 2008. Besides, natural gas discovered in Ordovician sandstone reservoirs in the Risha region, so the cumulative production of natural gas reached 169 bcf by the end of 2008[23].

Jordan's demand for natural gas did not begin until 1989 when it started its own production. Natural gas produced was almost all consumed domestically. Jordan experienced a major move in its natural gas consumption since 2003. In 2003 the country consumed an estimated 23 bcf of natural gas. In addition, the country produced 8 bcf in 2009 while consumed 108 bcf in the same year. Figure 12 shows a sharp decline in Jordan's natural gas demand from 108 bcf in 2009 to 37 bcf in 2011.

[23] US Energy Information Administration 2014.

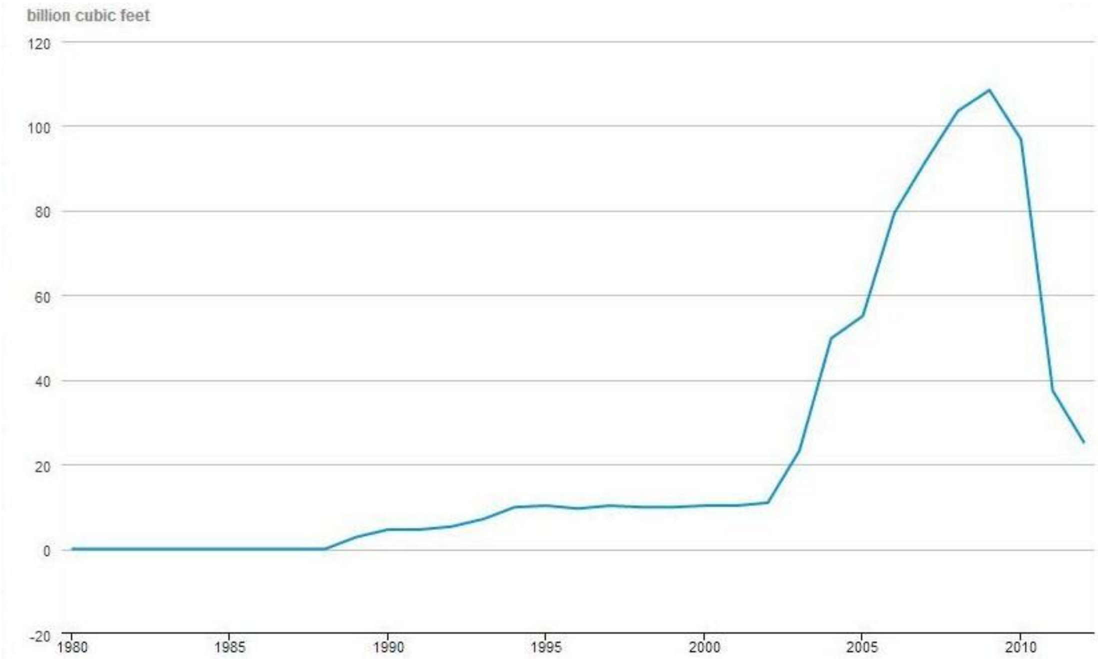

Fig. 12. Natural Gas Consumption in Jordan (1980-2011)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

As a result, the country announced several plans to import natural gas in order to meet its growing domestic need. The principal source of Jordanian natural gas imports is the recently completed Arab Gas Pipeline that runs from Al Arish terminal in Egypt underwater to Al Aqabah and then to northern Jordan. This Egypt–Jordan pipeline provides about 35 bcf of natural gas yearly to Jordan. However, imports decreased significantly from 89 bcf in 2010 to 29 bcf in 2011 due to instability in the Sinai Peninsula. Thus, Jordan is hunting various pipeline deals, especially with Iraq, to facilitate its energy security. One plan is to deliver Iraqi gas from region near Basra to the port of Aqaba on the Red Sea. According to this plan, this pipeline could supply Jordan with around 1 bcf daily[24]. In addition, the government is studying a plan to build a liquid gas terminal in the Port of Aqaba.

[24] US Energy Information Administration 2014.

The principal foundation of natural gas in Jordan is located in the eastern area of the country at the Risha gas field. Figure 13 clearly shows that natural gas reserves did not witness any major shock since 1995. Jordan is estimated to have modest natural gas reserves (about 0.24 tcf in 2000 and 0.21 tcf in 2011).

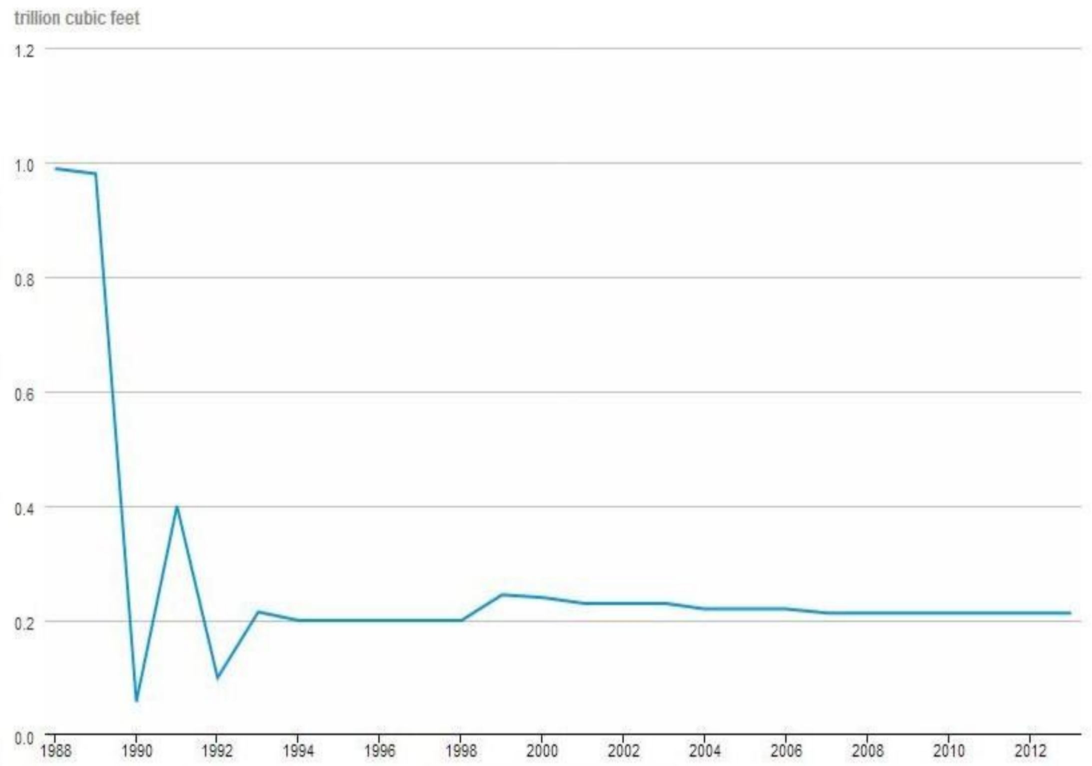

Fig. 13. Proven Natural Gas Reserves in Jordan (1980-2011)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

5. Morocco

Morocco which is located in the northwestern corner of the African continent is considered to be the largest energy importer in northern Africa. The high demand of hydrocarbons such as oil, gas and coal is met by just a very small portion of the country's domestic production.

Fig. 14. Natural Gas Production in Morocco (1980-2011)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

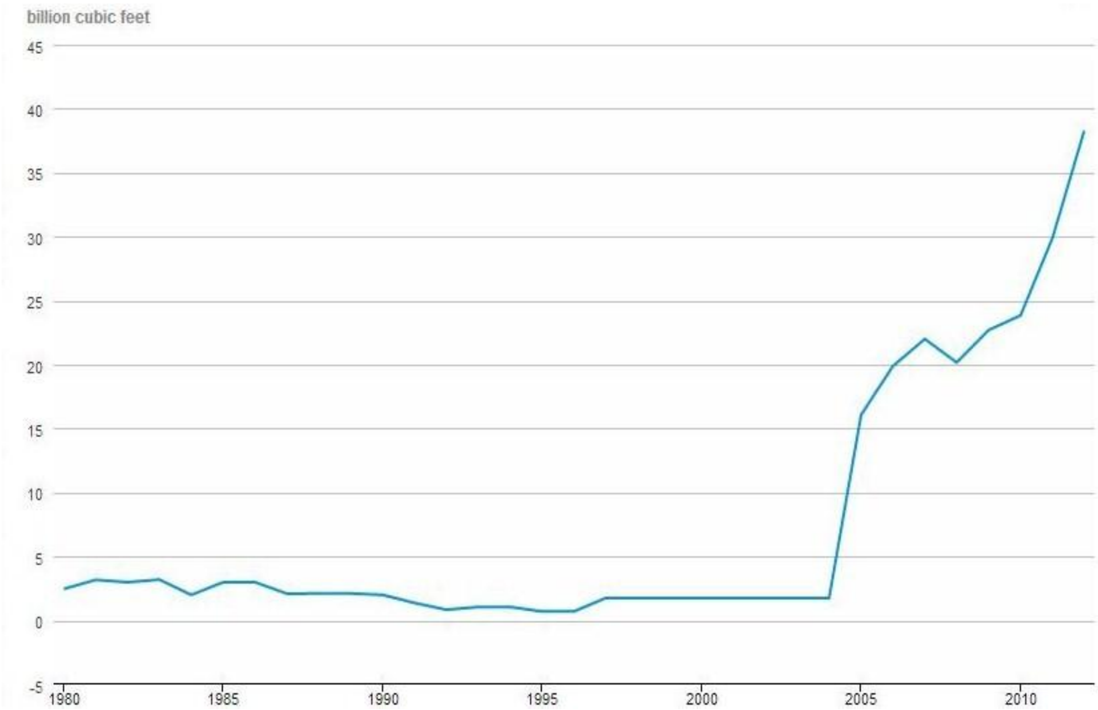

Fig. 15. Natural Gas Consumption in Morocco (1980-2011)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

Morocco generates marginal volumes of natural gas which are largely consumed domestically. The country produces diminutive amounts of natural gas from both the Essaouira Basin and the Gharb Basin. In the late 1980s, Morocco showed a major decline in natural gas production from 3.2 bcf in 1983 to 0.71 bcf in 1996 whereas consumption decreased from 3.2 bcf to 1.8 bcf during the same period. Starting from early 1990s, demand for natural gas has overweighed the country's rate of production. Production of natural gas has been somewhat stable over the past decade, with 2.1 bcf produced in 2011. Even though the country currently produces gas, production is limited relative to other African countries.

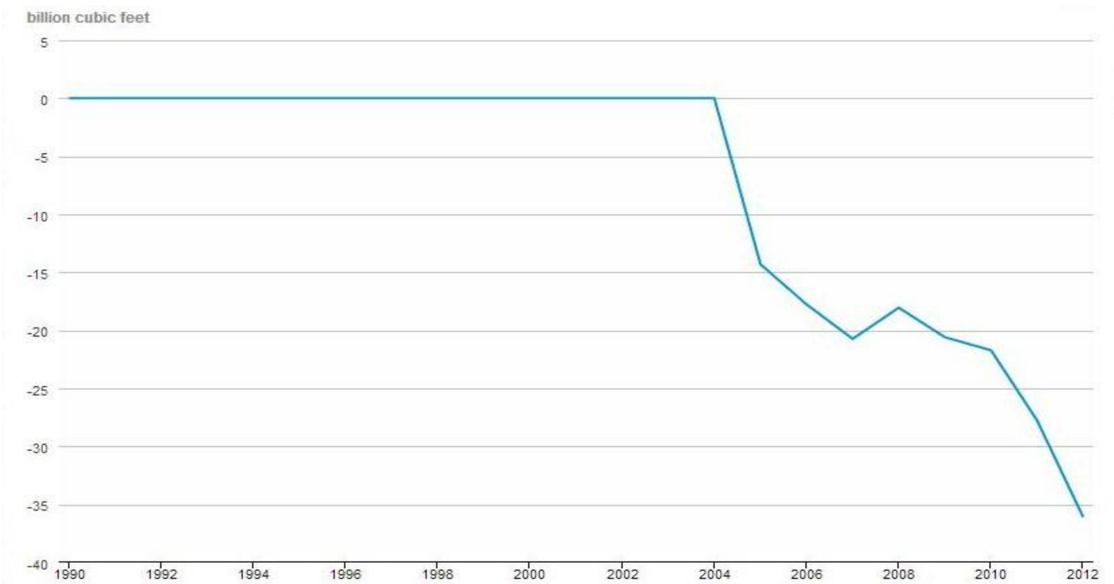

Fig. 16. Natural Gas Exports/ Imports (-) in Morocco (1990-2011)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

Consequently, Morocco relied heavily on its imports of natural gas to fulfill its domestic need. Morocco presently attains almost all of its natural gas from its neighbor Algeria through the Europe Maghreb pipeline which links the Algerian gas fields of

Hassi R'Mel to the Spanish gas pipeline network starting 1996. It is also considered as a transit hub for natural gas coming from Algeria to Spain and Portugal. All in all, Morocco obtains each year about 21 bcf of natural gas through the Europe Maghreb Pipeline[25].

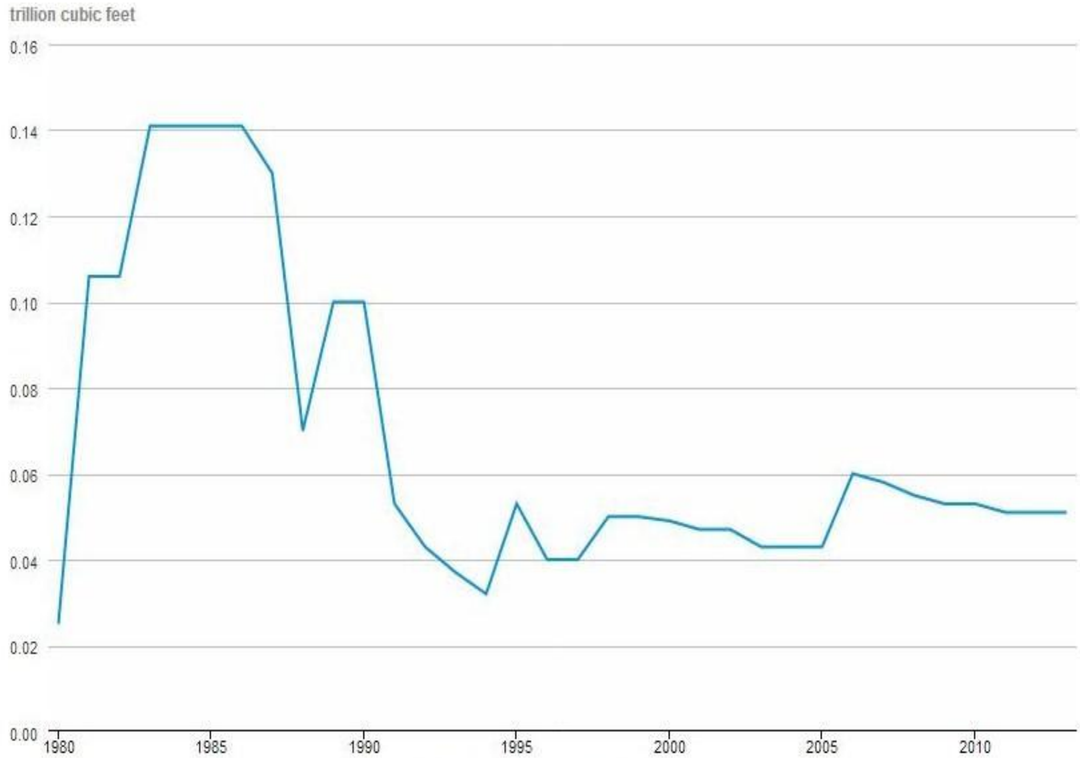

Fig. 17. Proven Reserves of Natural Gas in Morocco (1980-2011)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

In the early 1980s, Morocco enjoyed about 141 bcf of proven natural gas reserves. On the contrary, as demand increased, the sources of natural gas showed a significant decline by more than 50% to reach just 51 bcf in 2011.

[25] US Energy Information Administration 2014.

6. Oman

Oman which is situated on the southeast coast of the Arabian Peninsula is believed to be the largest producer of oil and natural gas in the Middle East that is not a member of the OPEC[26]. The geographical location of Oman joining the Arabian Sea, Gulf of Oman, and Persian Gulf provides it with access to some major energy passages. This justifies the country's position in the international supply chain. Oman like its neighbors relies heavily on its hydrocarbons sector which account for 86% of government revenues according to 2012 estimates. In fact, oil and natural gas provided about 40% of Oman's GDP in 2012. Natural gas accounted for 30% of the total primary energy consumption in 2011. Oman which is member of the GECF[27] uses considerable portion of its produced gas for re-injection functions to extort oil. For instance, Oman used 22% of its dry production for oil extraction in 2012[28].

Table 7. Some Energy Facts in Oman (2006-2010)

Basic Energy Facts	2006	2007	2008	2009	2010e
Total Energy Consumption (mtoe)*	14.2	14.9	18	..	..
CO2 Emissions, energy-related (Mt)	35.58	37.66	44.51	48.90	..
CO2 intensity, energy-related (tCO2/toe)	..	..	..	..	..
Energy consumption per capita (toe/cap)*	5.15	5.33	6.29	..	..
CO2 per capita, energy-related (tCO2/cap)	12.95	13.45	15.60	16.80	..
c = confidential; - = nill; .. = not available					

Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

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[26] Organization of Petrolum Exporting Countries

[27] Gas Exporting Countries Forum

[28] US Energy Information Administration 2014.

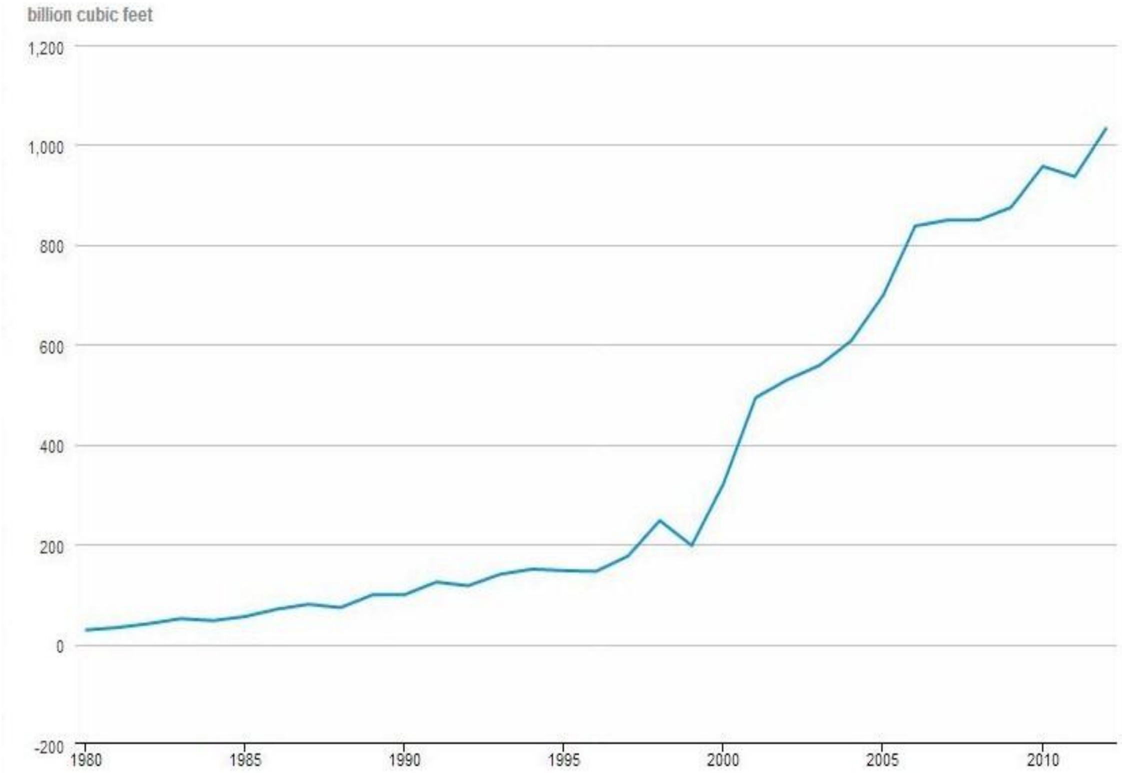

Fig. 18. Production of Natural Gas in Oman (1980-2011)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

Before 2000, Oman produced inconsiderable amounts of dry natural gas varying between 100 bcf and 200 bcf during 1990-1999. Then, the dry natural gas production was stimulated by the creation of the Oman LNG facility. Natural gas production in Oman has experienced continuing rise since 2000; natural gas production increased by 66% between 2000 and 2011 (nearly 390 bcf) due to several reasons mainly increased domestic demand (168% increase between 2002 and 2011) and export restrictions. In 2011, Oman producing 0.93 tcf of dry natural gas was considered as the 5th largest producer in the Middle East and the 26th in the whole world.

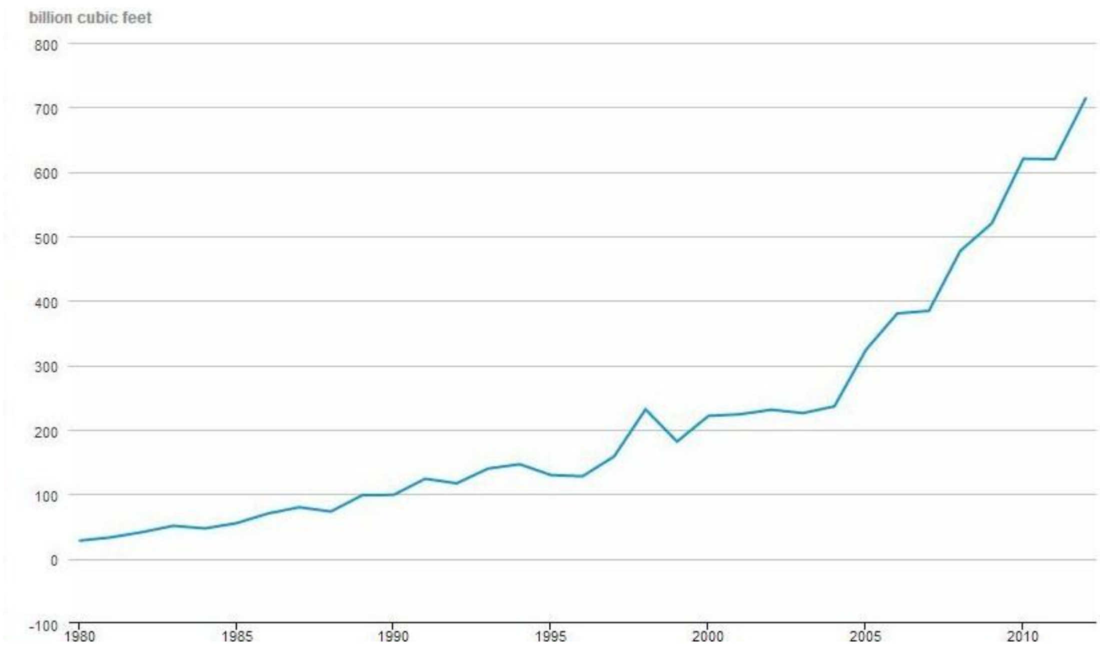

Fig. 19. Production of Natural Gas in Oman (1980-2011)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

Table 8. Some Gas Facts in Oman (2006-2010)

Basic Gas Facts	2006	2007	2008	2009	2010e
Gas reserves (bcm)	..	690	690	610	614
Gas production (mcm)	27049	27402	27824	28821	31538
Gas consumption (mcm)	11006	11489	11863	12811	15235
Gas imports (mcm)			1852	1634	2070
-imports pipeline (mcm)			1852	1634	2070
-imports LNG (mcm)					
import dependency (%)*	0%	0%	0%	0%	0%
Gas exports (mcm)	12245	12526	11277	11945	11498
Natural gas supply per capita (toe)	..	..	..	..	..
Technically recoverable shale gas resources (bcm)	..	..	..	..	..
Coal Bed Methane reserves (bcm)**	..	..	..	..	..
c = confidential; - = nill; .. = not available					

Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

Oman is not a major importer of natural gas. Oman imports some natural gas from Qatar to meet its rapid growing domestic consumption. All the gas imported which amounts about 71 bcf yearly comes via Oman's single international pipeline, the Dolphin pipeline which is the first cross-border pipeline in the Gulf region running from Qatar to Oman throughout the United Arab Emirates[29]. According to Table 8, total imports of natural gas were 2070 mcm[30] in 2010, a 26.7% increase compared to 2009 (1637 mcm).

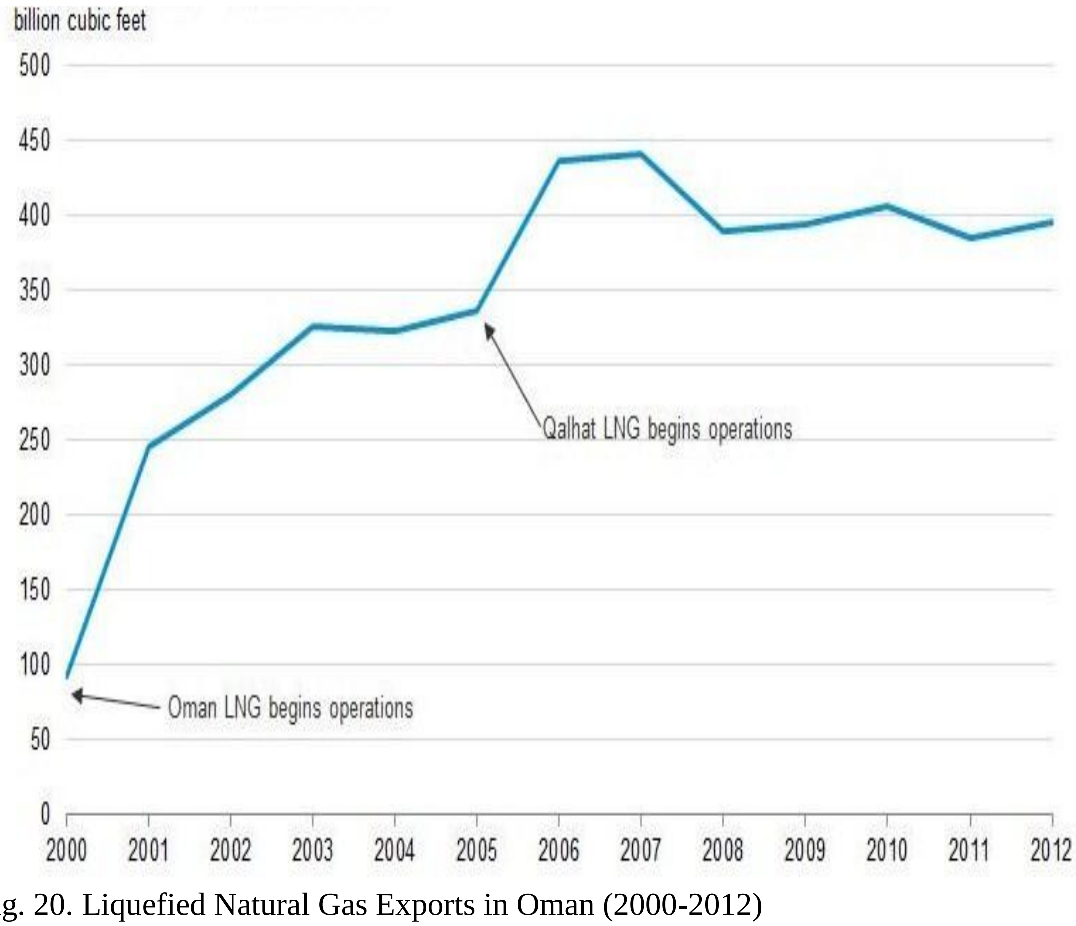

Fig. 20. Liquefied Natural Gas Exports in Oman (2000-2012)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

[29] US Energy Information Administration 2014.

[30] Million Cubic Meters

Table 9. Exports by Country in Oman (2006-2010)

By country of destination (in mcm)	2006	2007	2008	2009	2010	%Total 2010
China		82		90	86	0.75%
Chinese Taipei	328	250	83	165	510	4.44%
India	272	272	410	345		
Japan	4010	5179	4290	3896	3725	32.40%
Korea	6817	6420	6323	5943	5946	51.71%
Kuwait				85	890	7.74%
Spain	818	323	5125	1421	341	2.97%
Total	12245	12526	16231	11945	11498	100%
%Total Production	45.27%	45.71%	58.33%	41.44%	36.46%	

Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

Table 10. Exports by Transportation Type in Oman (2006-2010)

By transport type (in mcm)	2006	2007	2008	2009	2010	%Total 2010
Pipeline imports						
LNG imports	12245	12526	16231	11945	11498	100%
Total	12245	12526	16231	11945	11498	100

Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

All of Oman's exported natural gas is transported in the form of LNG via its two liquefaction facilities near Sur, in the Gulf of Oman. The total exports of natural gas are 11.5 bcm in 2010 which accounted for 36% of the total production of the same year. In 2011, almost all of natural gas exports (10.9 bcm) go to Japan (5.4 bcm) and South Korea (5 bcm)[31].

[31] BP Statistical Review of World Energy 2012.

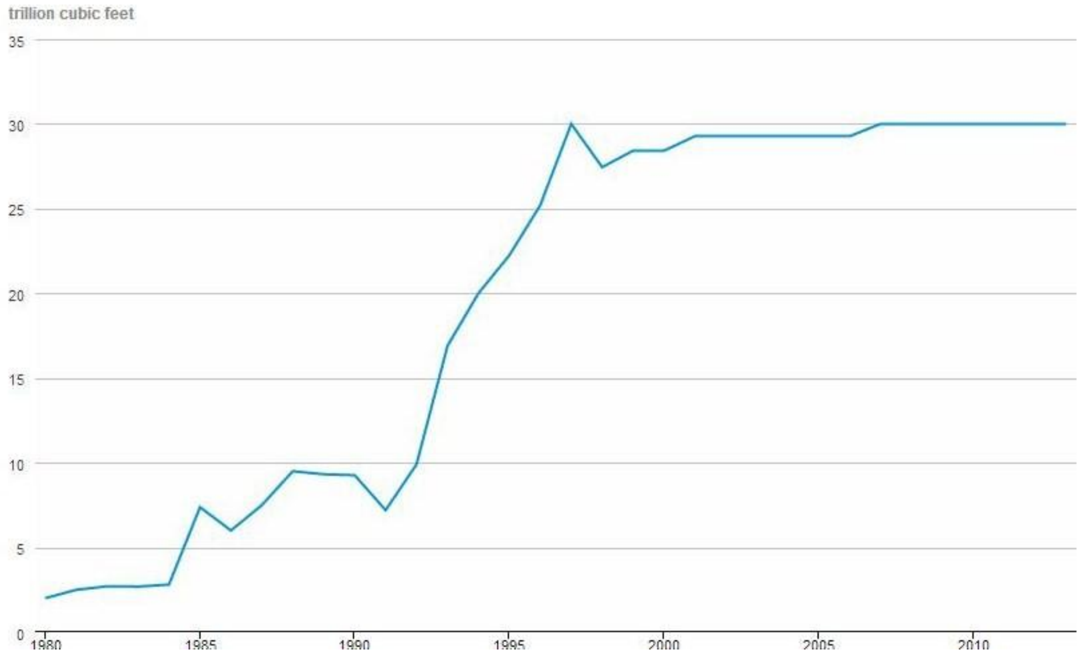

Fig. 21. Proven Natural Gas Reserves in Oman (1980-2010)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

Since 2000, the proven natural gas reserves have shown a major increase. Oman held estimated total proved natural gas reserves of 33.5 tcf in 2011, which is approximately 0.5% of total world's reserves. The reserves-to-production ratio for Oman is 35.8[32] years.

7. Saudi Arabia

Saudi Arabia which is located in the Arabian Peninsula is one of the largest energy producers and consumers in the entire world. Saudi Arabia which is the 2nd largest country in terms of landmass in the Arab world after Algeria was announced to be the 13th largest user of total primary energy in 2009. In addition, it consumed about 201 mtoe of total primary energy which was estimated to be 7% increase than the previous year and natural gas accounted for 38% (76 mtoe) of total energy consumed.

[32] BP Statistical Review of World Energy 2012.

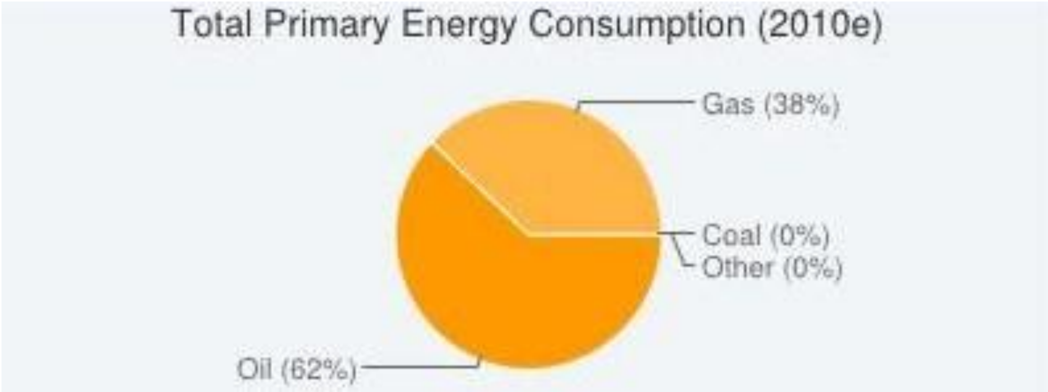

Fig. 22. Total Primary Energy Consumption in Saudi Arabia (2010)
Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

Table 11. Some Energy Facts in Saudi Arabia (2006-2010)

Basic Energy Facts	2006	2007	2008	2009	2010e
Total Energy Consumption (mtoe)	158.48	165.19	179.55	187.80	201.01
CO2 emissions, energy-related (Mt)	406.14	396.47	425.71	438.25	..
CO2 intensity, energy-related (tCO2/toe)	..	..	..	..	..
Energy consumption per capita (toe/cap)	7.24	6.44	7.61	7.79	..
CO2 per capita, energy-related (tCO2/cap)	16.87	16.18	17.09	17.30	..
c = confidential; - = nill; .. = not available					

Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

Figures 23 and 24 provide clear evidence that production and consumption of natural gas are moving in parallel, so demand of natural gas is met by the domestic production. In 2011, Saudi Arabia produced 99.2 bcm of natural gas, 13.2% more than in the previous year and 3% of the total world production. In return, it consumed exactly the same amount produced in the same year. Saudi Arabia has produced almost exactly as much as it needed for 1980-2011. As a result, it has no net imports or exports of natural gas during this period of time.

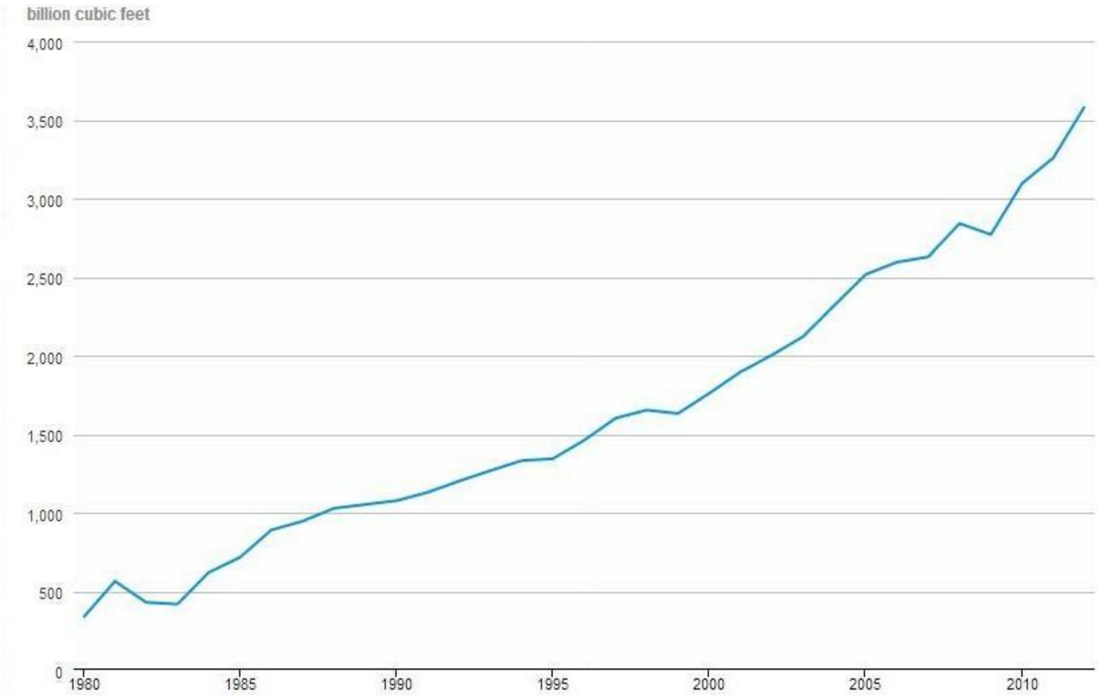

Fig. 23. Natural Gas Production in Saudi Arabia (1980-2010)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

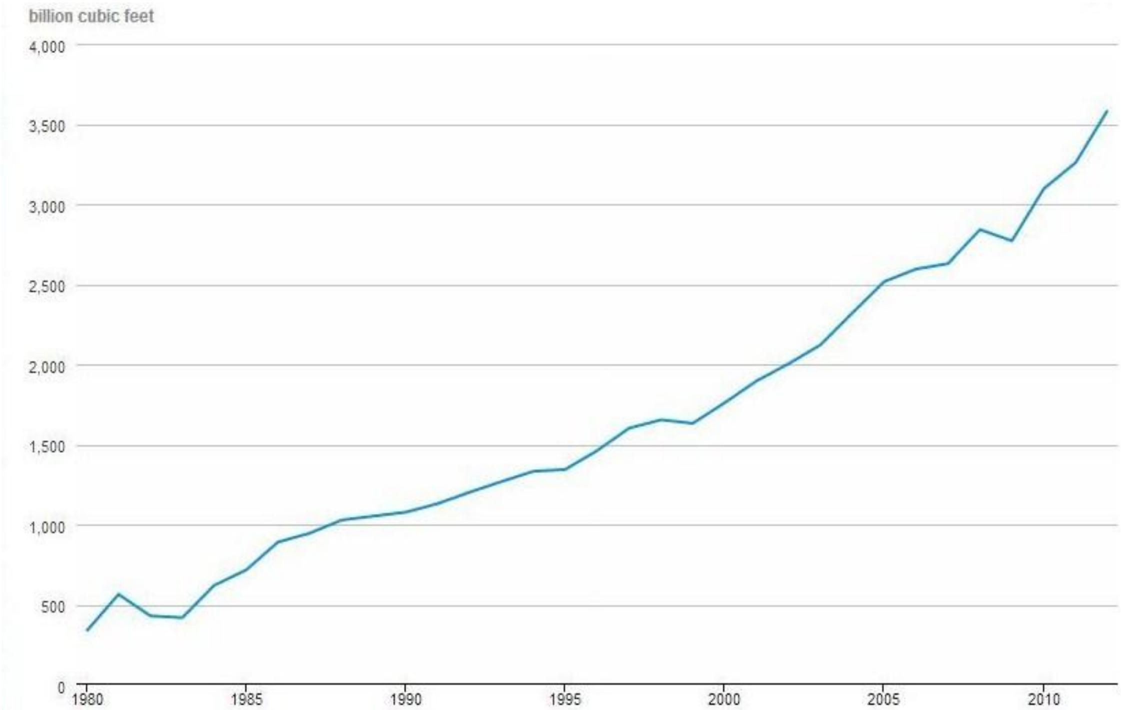

Fig. 24. Natural Gas Consumption in Saudi Arabia (1980-2010)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

Table 12. Some Gas Facts in Saudi Arabia (2006-2010)

Basic Gas Facts	2006	2007	2008	2009	2010e
Gas reserves (bcm)	..	7300	7550	7920	7835
Gas production (mcm)	72218	70464	74747	75123	81877
Gas consumption (mcm)	72218	70464	74747	75123	81877
Gas imports (mcm)	..	..	..	..	..
-imports pipeline (mcm)	..	..	..	..	..
-imports LNG (mcm)	..	..	..	..	..
Import dependency (%)*	..	..	..	..	..
Gas exports (mcm)	..	..	..	..	..
Natural gas supply per capita (toe)	..	..	..	..	..
Technically recoverable shale gas resources (bcm)	..	..	..	..	..
Coal Bed Methane reserves (bcm)**	..	..	..	..	..
c = confidential; - = nill; ..= not available					

Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

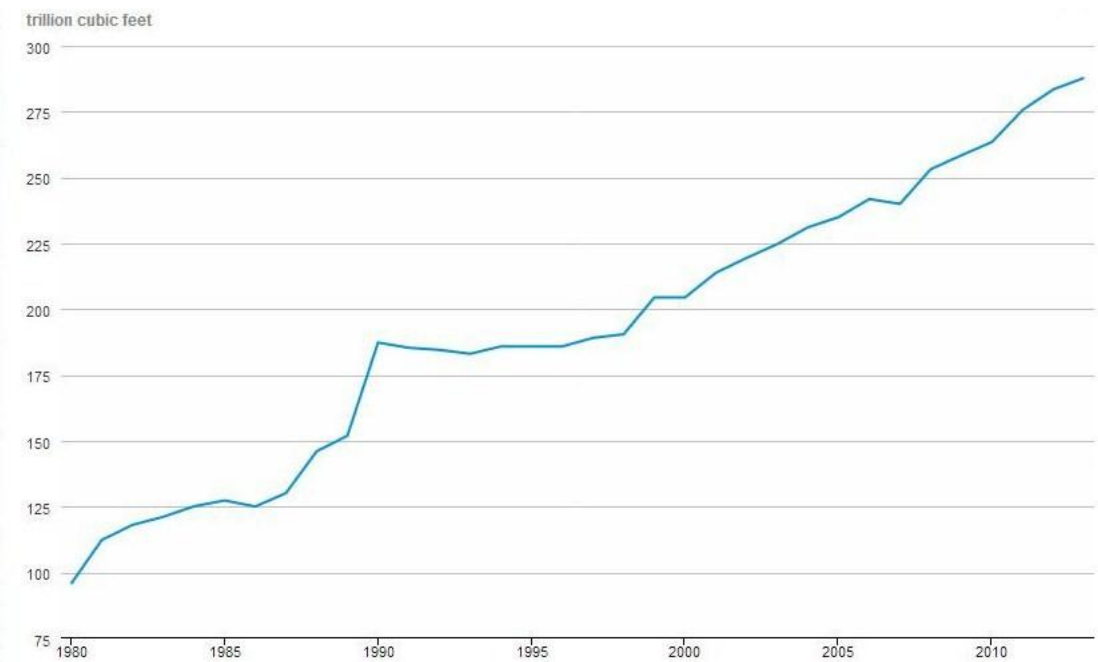

Fig. 25. Proven Natural Gas Reserves in Saudi Arabia (1980-2010)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

Although Saudi Arabia's natural gas production is limited relative to other countries in the Arab world, it had proven natural gas reserves of about 288 tcf at the end of 2011 representing 3.9% of the world's natural gas reserves. It had the world's 6th largest natural gas reserves behind Russia, Romania, Iran, Qatar and the United States. Over the last decade, it added more than 60 tcf of natural gas reserves[33]. The reserve to production ratio for Saudi Arabia was estimated to be 82 years in 2011[34].

8. Tunisia

Tunisia which is a North-African country bordering the Mediterranean Sea between Algeria and Libya is a relatively small hydrocarbon producer with respect to its neighbors. On the contrary, the country is increasingly turning to natural gas to fulfil its national growth of energy demand. In fact, natural gas represents a main source of energy necessities in Tunisia accounting for 44% (152 bcf) of the total primary energy consumption in 2005, compared to just 14% (130 bcf) in 2003.

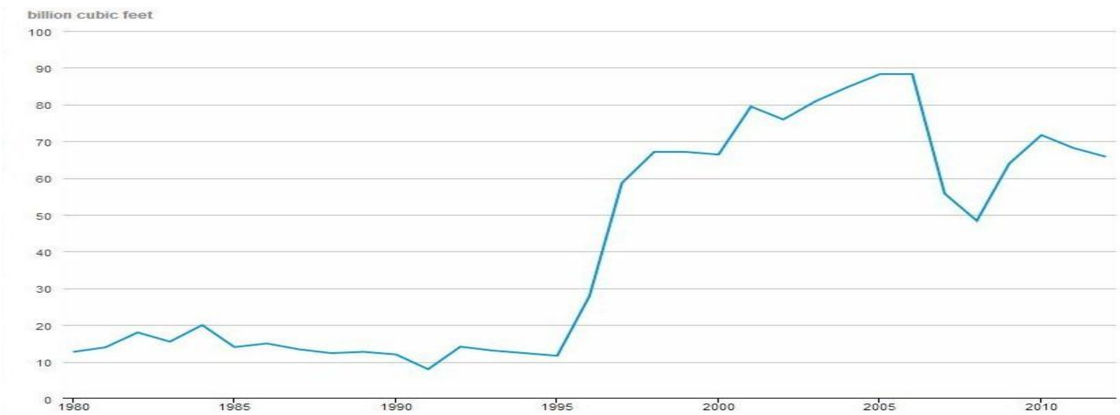

Fig. 26. Natural Gas Production in Tunisia (1980-2010)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

[33] US Energy Information Administration 2014.

[34] BP Statistical Review of World Energy 2012.

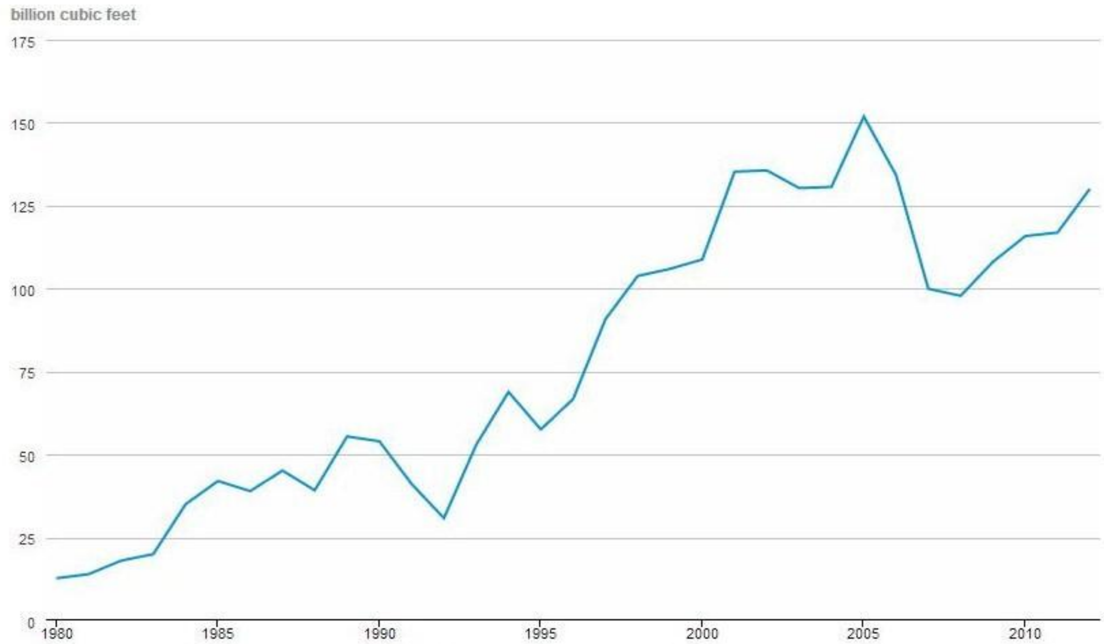

Fig. 27. Natural Gas Consumption in Tunisia (1980-2010)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

Both production and consumption of natural gas were moving in parallel during 1980-2011. In 2005, Tunisia attained its highest level of production of natural gas that is 88 bcf, while the country consumed about 152 bcf of natural gas during the same year. Then, natural gas production as well as consumption levels decreased slowly. In 2010, Tunisia produced 72 bcf of natural gas the majority of which originated from the Miskar and Franig fields whereas demand recorded 116 bcf. Most of the country's gas is generated from the Miskar field which was discovered in 1975. Tunisia has four other producing natural gas fields which are: El Franning, El Borma, Baguel, and Zinnia. All in all, these fields produce the remaining natural gas demanded. The Trans-Mediterranean Pipeline which is also called Enrico Mattei carries out natural gas from Algeria to Italy passing through Tunisia. According to EIA, Tunisia receives natural gas as a royalty in lieu of transit fees.

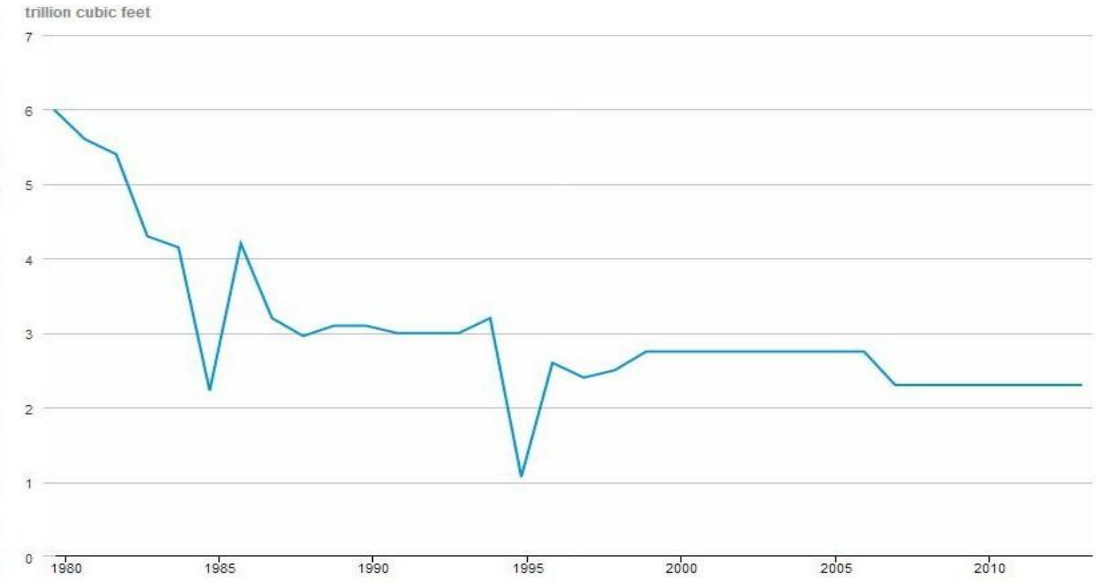

Fig. 28. Proven Reserves of Natural Gas in Tunisia (1980-2010)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

Since late 1980s, Tunisia's natural gas reserve has never exceeded 3.2 tcf. In 1995, Tunisia held the smallest volume of reserves (1 tcf) during 1980-2011. Tunisia has 2.3 tcf of proven natural gas reserves from 2009 till now. Besides, about two thirds of the reserves are located offshore[35].

9. Turkey

Owing to its geographical location at the crossroads of Europe and Asia, Turkey's role in the energy market as an energy transit hub and growing consumer is increasingly important. Besides being a key market for energy supplies, Turkey has experienced the fastest increase in energy demand over the last few years in the OECD. With regard to the natural gas world, Turkey holds a strategic role in importing of natural gas volumes of the Central Asian countries to the Western Energy Markets. It

[35] US Energy Information Administration 2014.

considered as a major energy terminal for gas exports. Natural gas share of the total energy mix is growing and it is overtaking that of oil. For example, in 2010, Turkey consumed about 104.80 mtoe of primary energy representing a 7.3% increase compared to 2009 (97.67 mtoe). Natural gas accounted for 30% of the total primary energy consumed, namely 31.4 mtoe. Thus, Natural gas has become the most important energy in terms of amount demanded.

Table 13. Some Energy Facts in Turkey (2006-2010)

Basic Energy Facts	2006	2007	2008	2009	2010e
Total Energy Consumption (mtoe)	93.03	100.01	98.5	97.66	104.8
CO2 Emissions, energy-related (Mt)	..	265	263.53	256.31	..
CO2 intensity, energy-related (tCO2/toe)	..	2.65	2.68	2.62	..
Energy consumption per capita (toe/cap)	1.39	1.48	1.43	..	..
CO2 per capita, energy-related (tCO2/cap)	..	3.59	3.71	3.57	..

c = confidential; - = nill; .. = not available

Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

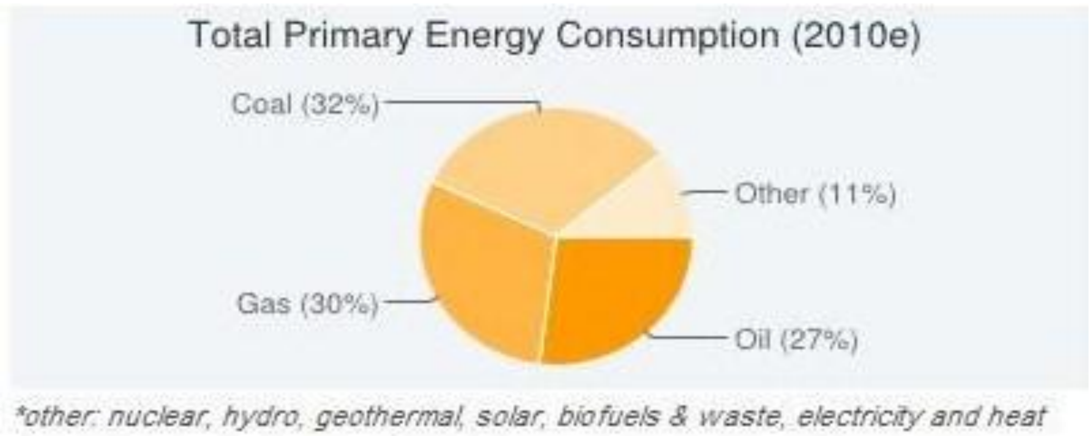

Fig. 29. Total Primary Energy Consumption in Turkey (2010)
Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

From the early 2000s, the significance of natural gas for Turkey's economy has extensively improved. Turkey's natural gas is primarily used for power generation. For instance, of total natural gas consumption in 2009, 57% of the natural gas consumed was used by the electric power sector while each of the industrial and residential sectors accounted for only 15%.

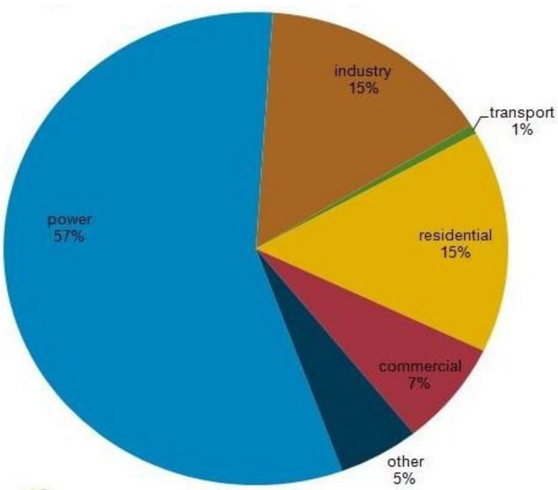

Fig. 30. Consumption of Gas by Sector in Turkey (2009)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

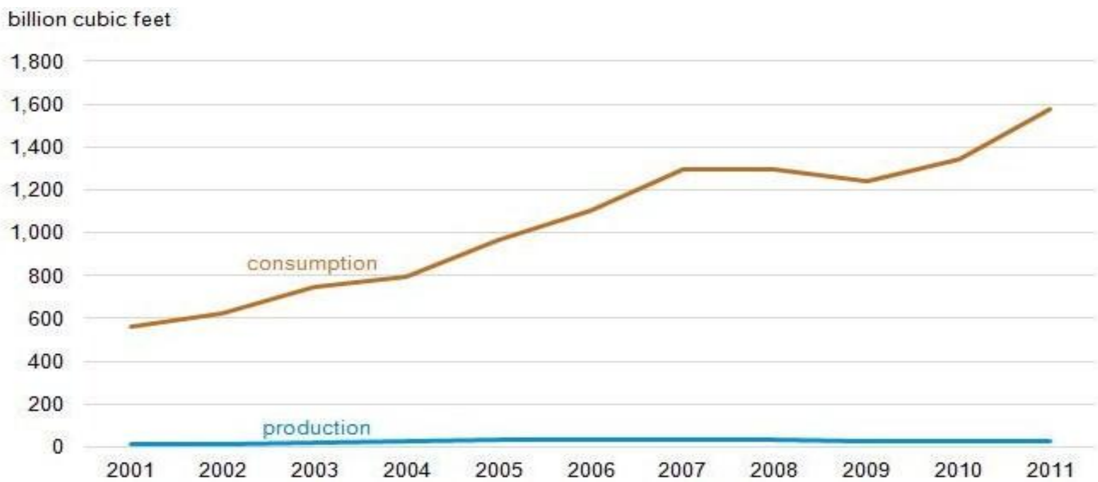

Fig. 31. Production and Consumption of Natural Gas in Turkey (2001-2011)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

Turkey's production of natural gas has started by the end of 1970s. As we can see from the above figure, Turkey produces very limited amount with respect to its growing demand. For instance, in 2003, the domestic production of natural gas accounted for 19.7 bcf representing about 2.6% only of Turkey's natural gas consumption (748 bcf). In 2010 Turkey consumed a total of 1.24 tcf of natural gas indicating over than 50% increase compared to 2003 (0.75 tcf). Natural gas demand growth in Turkey has been among the fastest in the world during 2010-2011. Turkey's demand for gas reached a peak of more than 1.5 tcf in 2011 with a very small amount of total production amounting to 27 bcf. Thus, Turkey depends largely on imports of gas to meet domestic demand.

Table 14. Imports by Country in Turkey (2006-2010)

By country of origin (in mcm)	2006	2007	2008	2009	2010	%Total 2010
Azerbaijan	..	1258	4580	4960	4521	11.89%
Iran	5594	6054	4113	5252	7766	20.42%
Russia	19316	22752	22962	19473	17575	46.21%
Algeria	4130	4205	4148	4487	3907	10.27%
Egypt					270	0.71%
Nigeria	1100	1396	1017	903	1189	3.13%
Qatar					1845	4.85%
Trinidad & Tobago					240	0.63%
Other	76	1425	333	781	724	1.90%
Total	30219	35832	37153	35856	38037	100%
%Total Consumption	96.91%	97.90%	101.39%	102.11%	99.78%	
c = confidential; - = nill; .. = not available						

Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

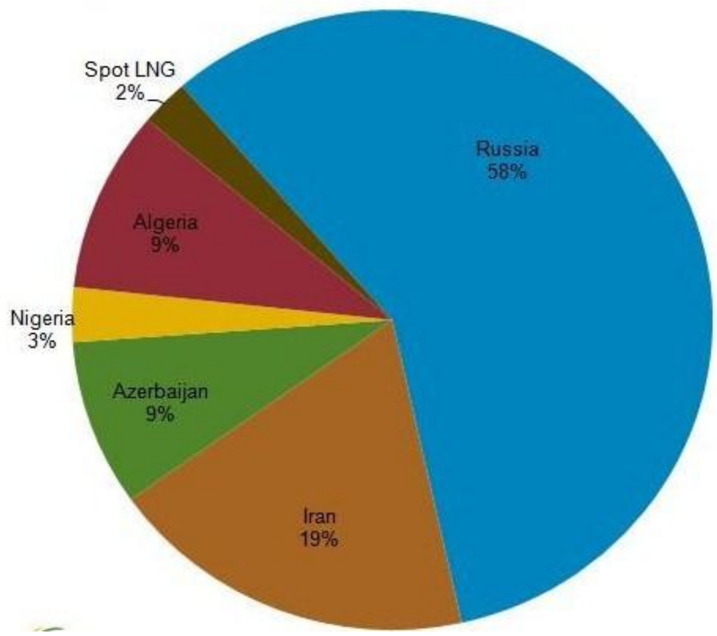

Fig. 32. Imports by Country in Turkey (2011)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

Table 15. Imports by Type in Turkey (2006-2010)

By transport type (in mcm)	2006	2007	2008	2009	2010	%Total 2010
Pipeline imports	24910	30064	31655	29685	29862	79%
LNG imports	5309	5768	5498	6171	8175	21%
Total	30219	35832	37153	35856	38037	100%
c = confidential; - = nill; ..= not available						

Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

With a relatively small national production and high demand growth, the country is increasingly depending on imported natural gas. The majority of imported natural gas is transported through pipelines, yet Turkey also imports natural gas in the form of LNG via tankers. In 2010, 0.68 bcm of gas was produced which met only 1.8 % of domestic consumption. The rest was imported either by pipelines or as liquefied natural gas (LNG). Total imported gas amounted to 38 bcm. The largest amount was supplied by Russia (17.5 bcm). The share of pipeline imports was 79% against 21% for LNG. Further, in 2011, Turkey imported approximately 42 bcm of natural gas; 35.6 bcm via pipeline and 6.2 bcm as LNG. The largest share of the country's imported natural gas came from Russia 58 % namely, 23.5 bcm. Another 19% of the total came from Iran (8.4 bcm) the Tabriz-Dogubayazit pipeline. Sizeable shares also originated from Azerbaijan (9%) via the Baku-Tbilisi-Erzurum pipeline. The imported LNG which arrives at the country's two terminals, Marmara Ereglisi in Tekirdag and the Aliaga terminal in Izmir comes from different countries such as Algeria (4 bcm), Nigeria (1.3 bcm), Qatar (0.6 bcm) and Egypt (0.4 bcm).

Table 16. Basic Gas Facts in Turkey (2006-2010)

Basic Gas Facts	2006	2007	2008	2009	2010e
Gas reserves (bcm)	..	9	8	6	6
Gas production (mcm)	905	893	1017	684	674
Gas consumption (mcm)	31183	36599	36645	35115	38119
Gas imports (mcm)	30219	35832	37153	35856	38037
-imports pipeline (mcm)	24910	30064	31655	29685	29862
-imports LNG (mcm)	5309	5768	5498	6171	8175
import dependency (%)*	..	97.82%	100.2%	100.09%	98.08%
Gas exports (mcm)	..	31	435	708	649
Natural gas supply per capita (toe)	0.374	0.433	0.425	0.402	0.431
Technically recoverable shale gas resources (bcm)	..	..	..	424.8	..
Coal Bed Methane reserves (bcm)**	..	..	..	..	3000
c = confidential; - = nill; ..= not available					

Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

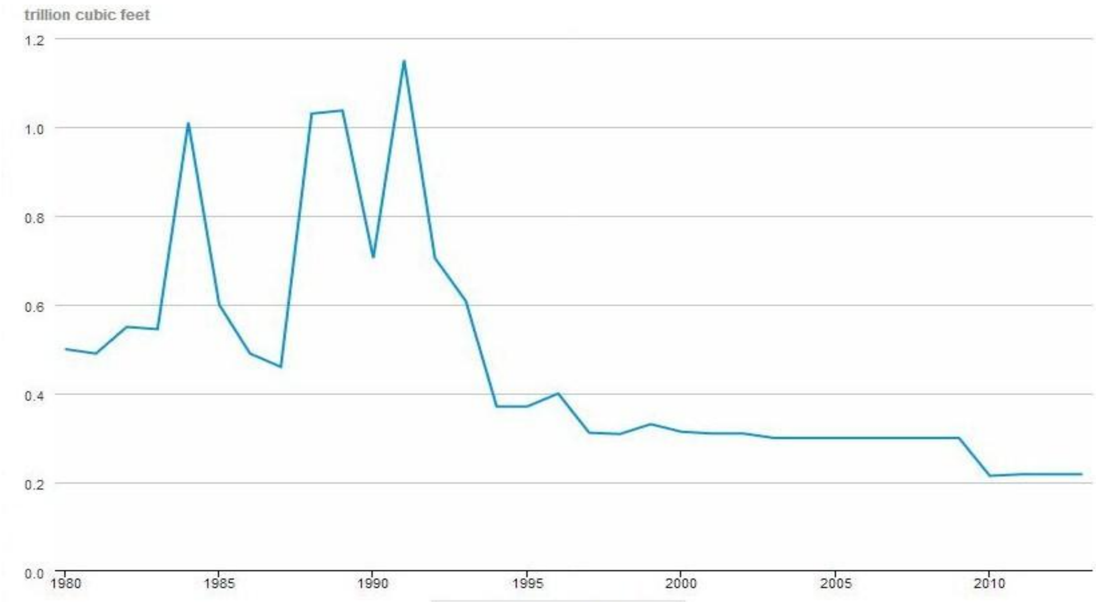

Fig. 33. Proven Natural Gas Reserves in Turkey (1980-2010)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

Turkey experienced a significant decline in its gas reserves in the early 1990s. As the demand for gas increases, the proven reserves decrease. Turkey's reserves of natural gas was at its peak in 1991 (1.15 tcf), then it has reduced by more than 50% by the end of 2010 (0.215 tcf). Turkey held a very limited amount of natural gas reserves around 218 bcf in 2011. Moreover, the reserve to production ratio for Turkey is estimated to be around 9 years which is relatively small.

10. United Arab Emirates

The United Arab Emirates which is located in the southeastern region of the Arabian Peninsula is a group of seven different emirates which together embrace the 3rd largest economy in the Middle East after Saudi Arabia and Iran. According to 2011 records, UAE achieved a GPD per capita of $48,158, making it the 5th global wealthiest economy per capita. Although it enjoys a diversified economy in the MENA region, UAE relies heavily on the hydrocarbons sector. The United Arab Emirates which is a member of the OPEC highly depends on oil and natural gas resources to support its economic development. For instance, revenues from hydrocarbon exports were $118 billion representing 80% of government revenues and namely more than half of the total exports in 2012. In addition, the total primary energy consumption in 2010 was estimated to be 86.8 mtoe, representing a 4.62% more than that of the previous year (83 mtoe), and natural gas accounted for 54.7 mtoe, namely 63% of the total primary energy consumption.

Table 17. Basic Energy Facts in UAE (2006-2010)

Basic Energy Facts	2006	2007	2008	2009	2010e
Total Energy Consumption (mtoe)	67.373	74.29	85.55	82.95	86.79
CO2 emissions, energy-related (Mt)	155.33	171.58	195.81	193.38	..
CO2 intensity, energy-related (tCO2/toe)	..	..	..	..	..
Energy consumption per capita (toe/cap)	14.99	16.02	17.95	17.12	..
CO2 per capita, energy-related (tCO2/cap)	36.41	38.61	42.37	40.30	..
c = confidential; - = nill; .. = not available					

Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

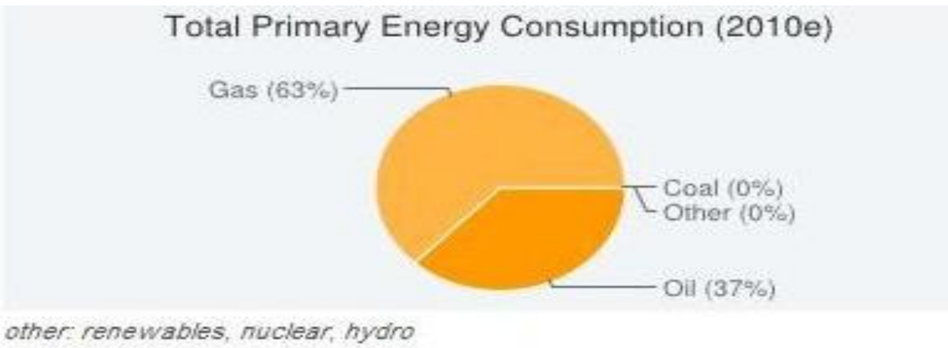

Fig. 34. Total Primary Energy Consumption in UAE (2010)
Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

Fig. 35. Natural Gas Production in UAE (1980-2011)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

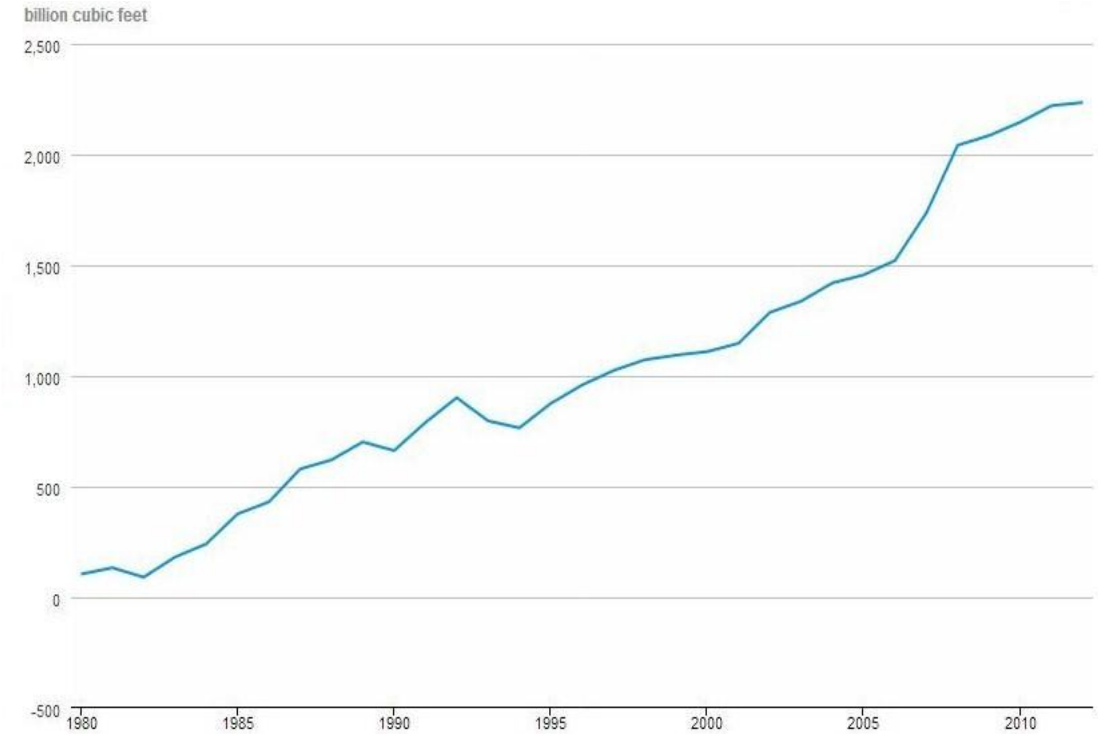

Fig. 36. Natural Gas Consumption in UAE (1980-2011)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

We can see clearly that as natural gas use is rising, production is increasing to provide part of the country's demand. According to EIA, UAE is considered as one of the 10 largest universal producers of natural gas. In 2011, the UAE produced 51.7 bcm of natural gas, 0.9% more than in the previous year. It produced 1.6% of the total world production of natural gas. In the same year, consumption of natural gas in UAE was about 63 bcm which is much higher than its own production level. Natural gas consumption increased by an average of more than 5% per year in the period 2003-2011, which moderately met its domestic production.

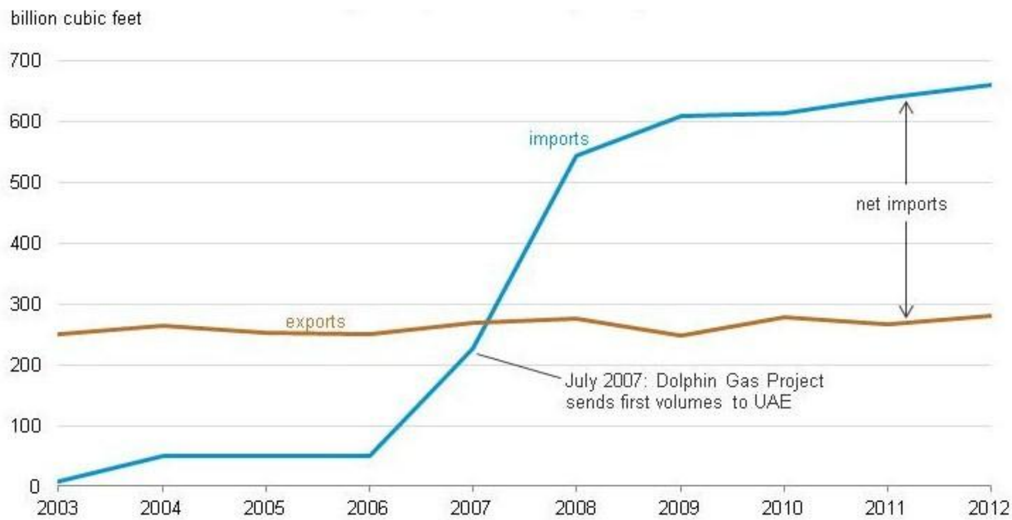

Fig. 37. Total Exports and Imports of Natural Gas in UAE (2003-2012)
Source: US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.

Despite its steadily rising demand for natural gas, UAE is considered as a net exporter of LNG. UAE exported about 8,057 mcm of LNG in 2010, accounting for 15.77% of its own domestic production. We can see that the total exports of LNG increased slightly from 15.23% in 2006 to 15.7% in 2010. In 2011, over than 95% of the UAE LNG exports went for Japan (7.7 bcm). The remaining volumes (0.3 bcm) mainly went to Taiwan and India. By the end of 2010, one operational LNG liquefaction terminal was created. The facility is called Das Island and was started up in 1977[36].

Table 18. Exports by Country of Destination in UAE (2006-2010)

By country of destination (in mcm)	2006	2007	2008	2009	2010e	%Total Exports 2010
Brazil					30	0.37%
Chinese Taipei					424	5.26%
India	91	80	130	163		
Italy						
Japan	7336	7800	7769	7123	7118	88.35%
Korea		74	31		245	3.04%
Kuwait					240	2.98%
Portugal				82		
Total*	7427	7954	7930	7368	8057	100%
%Total Production	15.23%	15.54%	15.79%	15.09%	15.77%	

Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

Despite being a member of the GECF, the UAE became an importer of natural gas in 2008. The increasing domestic demand for natural gas has caused the UAE to become a net importer. To achieve its growing demand for natural gas, the country increased its imports from neighboring Qatar through the Dolphin Gas pipeline which is one of the principal points of entry for the UAE natural gas imports linking Qatar's enormous natural gas reserves to UAE and Oman. The imported natural gas goes from

[36] US Energy Information Administration 2014.

Qatar's North Field to Abu Dhabi, Dubai, and Fujairah. Natural gas imports grew from just 6.4 bcm in 2007 to 17.3 bcf in 2010, while exports remained relatively flat through the entire period, rising by just 0.1 bcf over the same period. In 2011, the UAE imported 17.3 bcm of natural gas, which is approximately the same volume as in the previous year, representing 28.57% of its domestic consumption.

Table 19. Imports by Country in UAE (2006-2010)

By country of origin (in mcm)	2006	2007	2008	2009	2010e	%Total Imports 2010
Qatar	..	6450	15400	17250	17250	100%
Total	..	6450	15400	17250	17250	
%Total Consumption	..	12.93%	26.82%	29.43%	28.56%	
c = confidential; - = nill; ..= not available						

Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

Table 20. Imports by Type in UAE (2006-2010)

By transport type (in mcm)	2006	2007	2008	2009	2010e	%Total 2010
Pipeline imports	..	6450	15400	17250	17250	100%
LNG imports	..					
Total	..	6450	15400	17250	17250	
%Total Consumption	..	12.93%	26.82%	29.43%	28.57%	
c = confidential; - = nill; ..= not available						

Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

Table 21. Basic Gas Facts in UAE (2006-2010)

Basic Gas Facts	2006	2007	2008	2009	2010e
Gas reserves (bcm)	..	6437	6432	6090	6031
Gas production (mcm)	48750	51200	50230	48820	51093
Gas consumption (mcm)	43034	49865	57415	58618	60387
Gas imports (mcm)	1400	6450	15400	17250	17250
-imports pipeline (mcm)		6450	15400	17250	17250
-imports LNG (mcm)					
Import dependency (%)*			13.20%	17.46%	16.28%
Gas exports (mcm)	7080	7620	7820	7010	7422
Natural gas supply per capita (toe)	..	..	..	..	..
Technically recoverable shale gas resources (bcm)	..	..	..	..	..
Coal Bed Methane reserves (bcm)**	..	..	..	..	..
c = confidential; - = nill; .. = not available					

Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

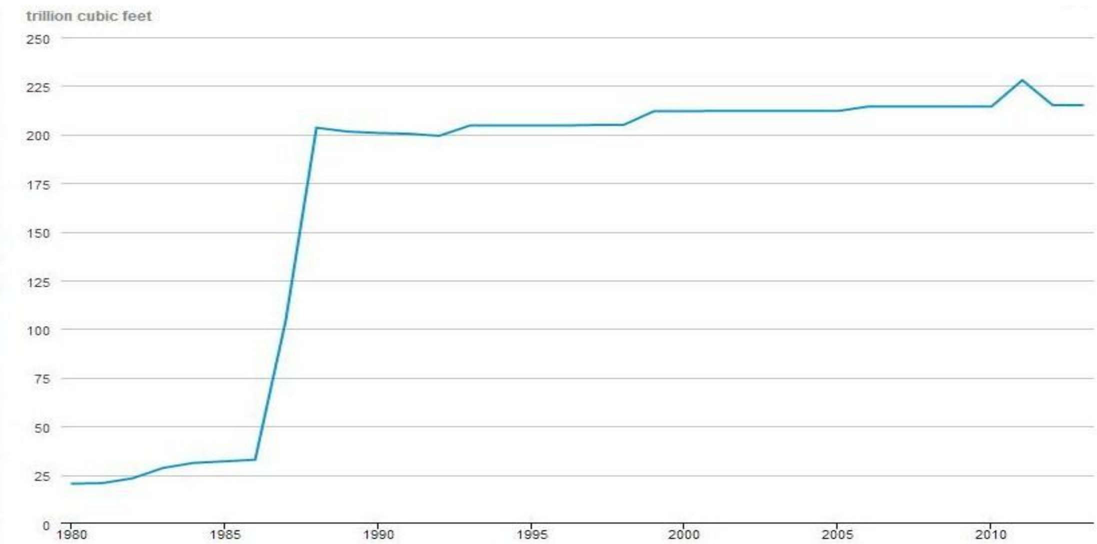

Fig. 38. Proven Natural Gas Reserves in UAE (1980-2010)
Source: Energy Delta Institution; available from http://www.energydelta.org; Internet; accessed 15 January, 2014.

In addition to being a major producer of natural gas, in 2011 UAE had the seventh largest total proven reserves of natural gas in the world after US, Russia, Romania, Iran, Qatar and Saudi Arabia. UAE held more than 215 tcf of natural gas reserves in 2011, which represents approximately 2.9% of the world total reserves. Abu Dhabi which is the capital of UAE holds the bulk reserves of natural gas (over 90% of the UAE total reserves) followed by Dubai (5%), with limited volumes in Sharjah and Ras Al Khaimah (2%). The reserve to production ratio for UAE was estimated to be more than 100 years at the end of 2011.

C. Comparative Analysis

Figure 39 shows time series plot graph of log natural gas consumption for each of the countries. Saudi Arabia is the biggest natural gas consumer while Morocco is the smallest. On the other hand, almost all countries in our sample have an increasing upward trend across the used period.

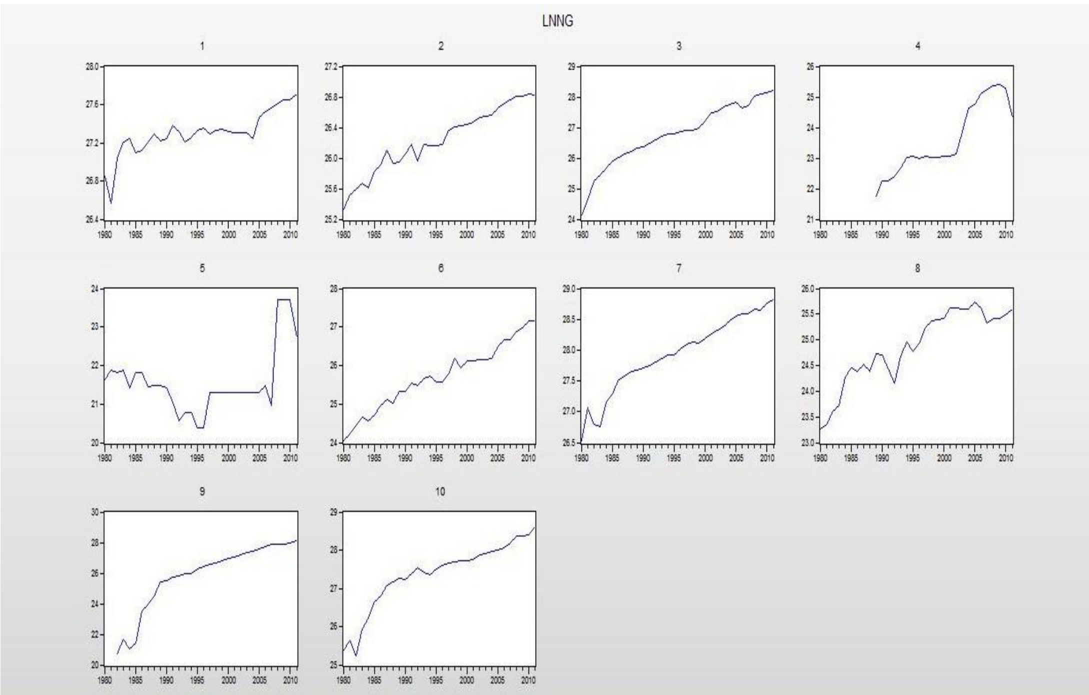

Fig. 39. Natural Logarithm of Natural Gas Consumption per Capita for Selected MENA Countries
Source: Eviews.

Figure 40 represents time series plot graph of log economic development per capita for every country. In fact, many countries have improved their economic development per capita across time. However, United Arab Emirates has some drop starting from 80's. In spite of the fall of economic growth per capita in UAE, it still has the highest GDP, whereas, Egypt has the lowest.

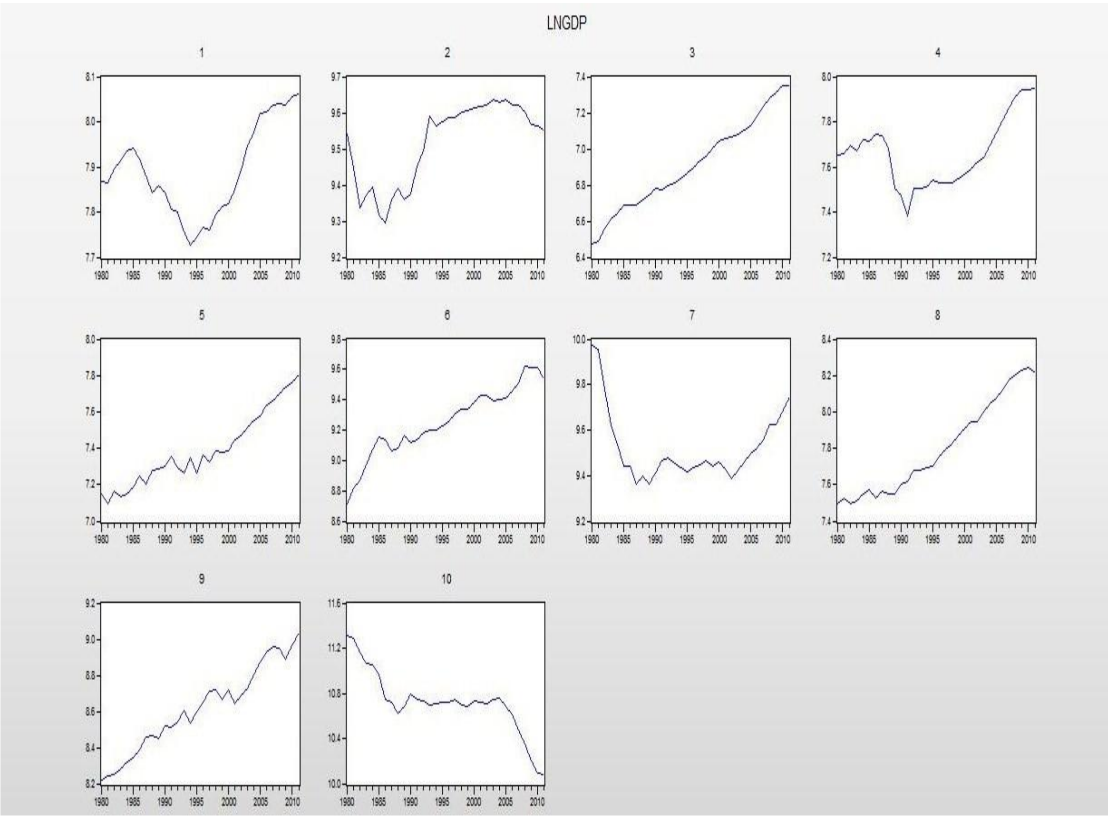

Fig. 40. Natural Logarithm of GDP per Capita for Selected MENA Countries
Source: Eviews.

The time series graph for log carbon dioxide emissions per capita for the 10 MENA countries is shown in Figure 41. Most of the countries have increased their carbon dioxide emissions per capita during 1980-2011. United Arab Emirates is the largest polluting country, as Morocco is the smallest.

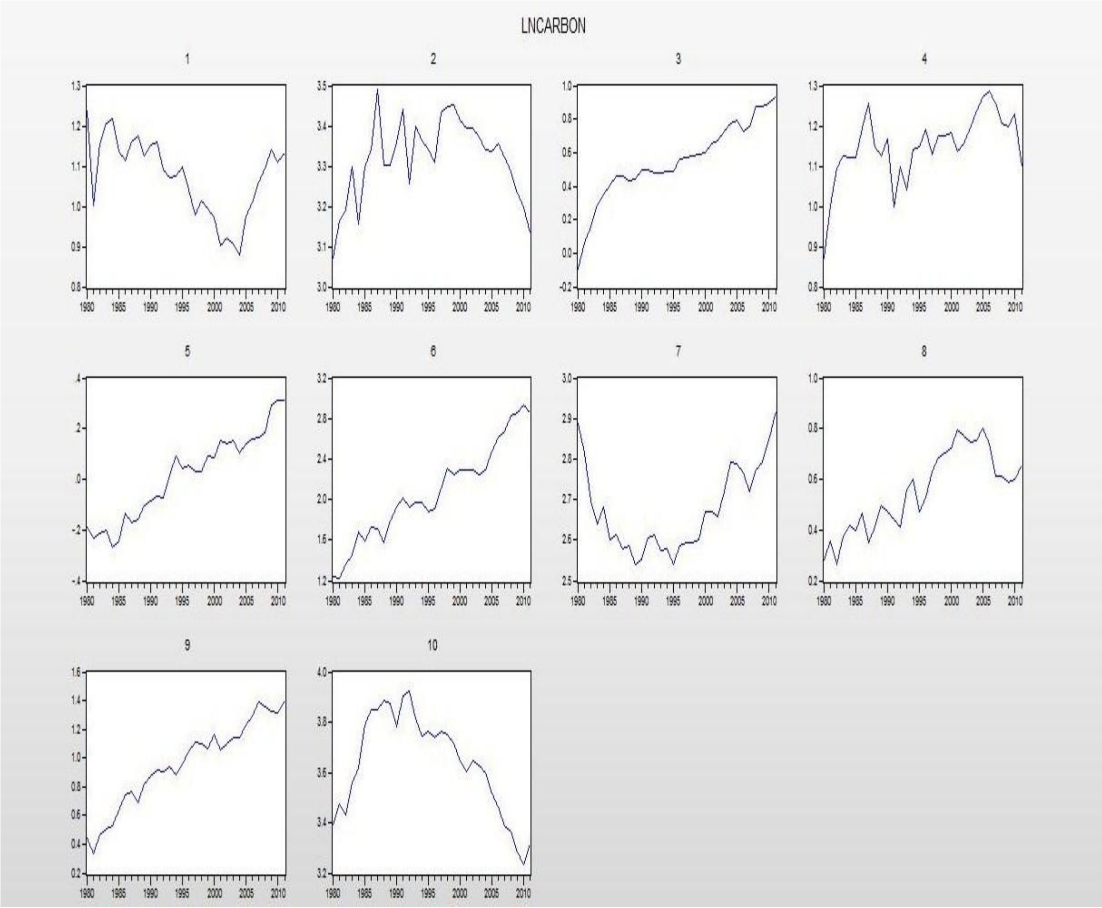

Fig. 41. Natural Logarithm of Carbon Emissions per Capita for Selected MENA Countries
Source: Eviews

Table 22 shows the average annual growth rates for each variable over 1990-2011. We can see that the average annual growth rate for natural gas consumption per capita differs between countries, and it varies from a low record of -0.8% to a very high value of 40.6%. Algeria, Bahrain, and UAE have the lowest natural gas consumption per capita while Turkey, Egypt, Jordan, and Oman have the highest value. On the other hand, some countries such as Algeria, Bahrain, and UAE stand out for having a low economic growth. Thus, the average annual growth rate for natural gas consumption per capita in these countries is parallel to their average annual growth rate for GDP per capita. In Turkey, the average annual growth rate in natural gas consumption per capita is important and growing more rapidly than its economic income growth rate. In fact, Turkey and Oman are two countries that have a positive average annual growth rate for carbon dioxide emissions per capita whereas UAE records a negative value.

Table 22. Average Annual Growth Rates Over 1990-2011

Country	NGC per capita	GDP per capita	CO_2 per capita
Algeria	0.51	1.17	-0.09
Bahrain	-0.79	0.92	-0.97
Egypt	16.41	3.64	2.59
Jordan	15.16	2.86	-0.31
Morocco	8.83	3.10	2.32
Oman	13.07	2.48	7.29
Saudi Arabia	3.65	1.90	2.10
Tunisia	4.06	4.00	0.96
Turkey	40.61	3.23	3.29
UAE	-0.89	-2.44	-1.77
Total	10.06	2.08	1.54

We first provide briefly a summary on the statistics of each variable to check whether they are normally distributed. Accordingly, histograms of the above mentioned variables (in logarithms form) are plotted, coupled with statistical indicators such as skewness (S) and kurtosis (K).

For economic growth and carbon dioxide emissions, results in Figures 43 and 44 show a positive skewness (0.387and 0.460), indicating the existence of a distribution with an asymmetric tail extending toward more positive values, while Figure 42 results show a negative skewness of -0.783, indicating the existence of a long left tail of the distribution for natural gas consumption.

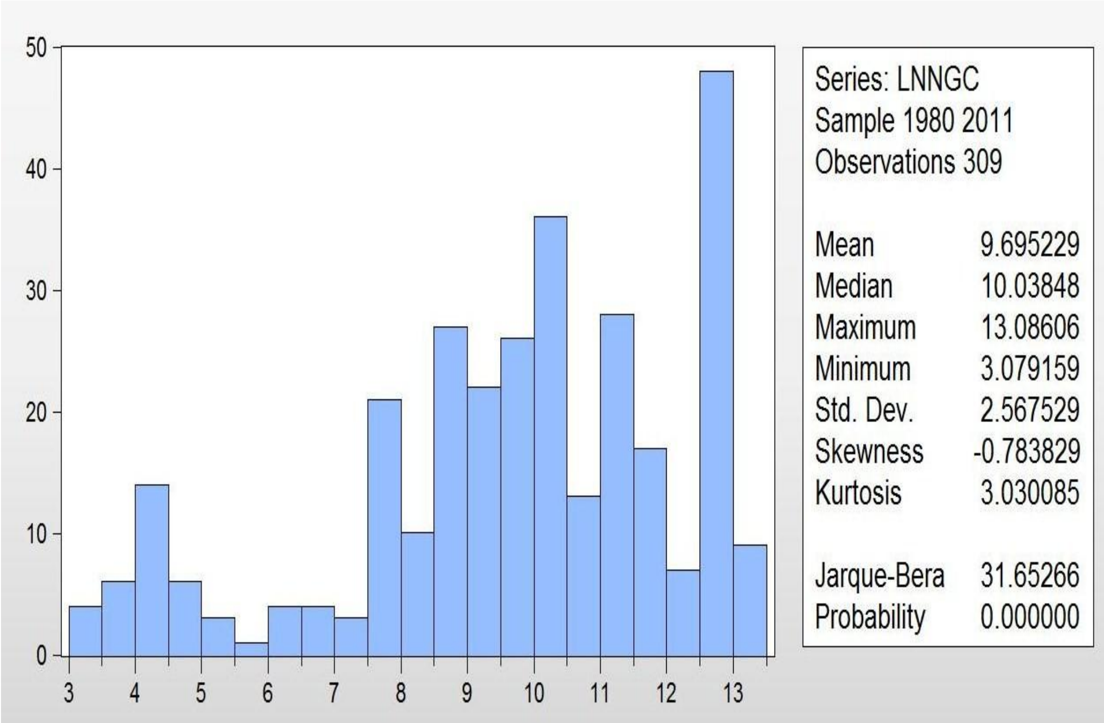

Fig. 42. Statistical Properties of Natural Gas Consumption Per Capita
Source: Eviews

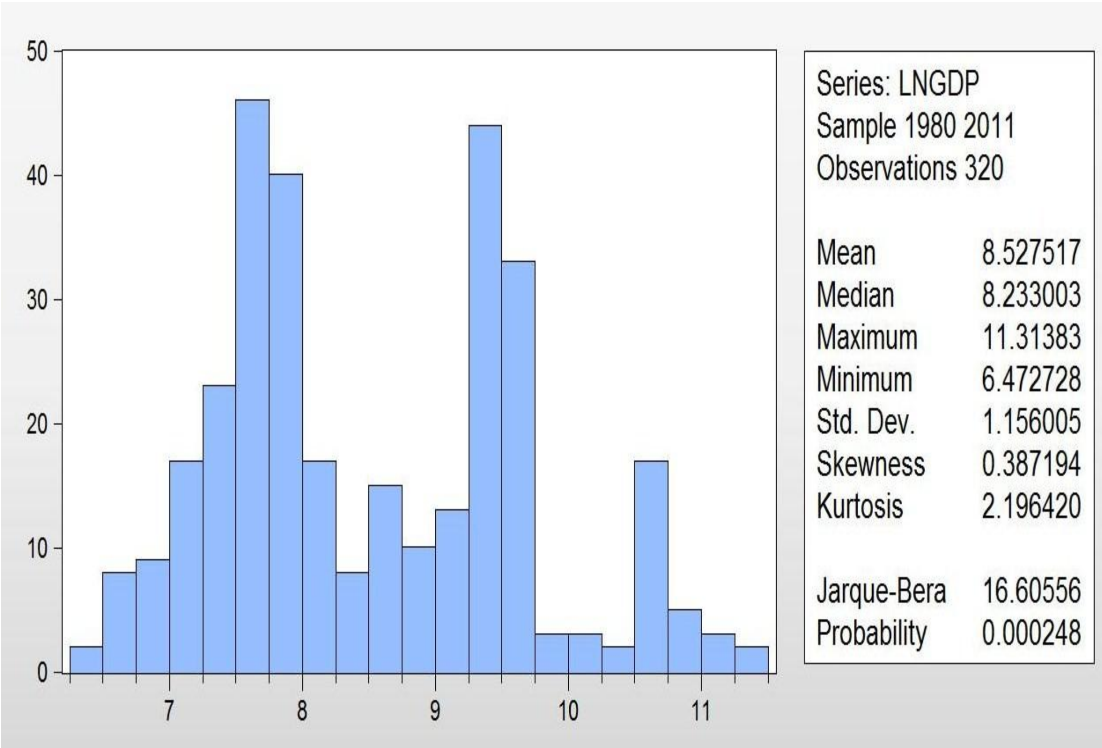

Fig. 43. Statistical Properties of Economic Growth Per Capita
Source: Eviews

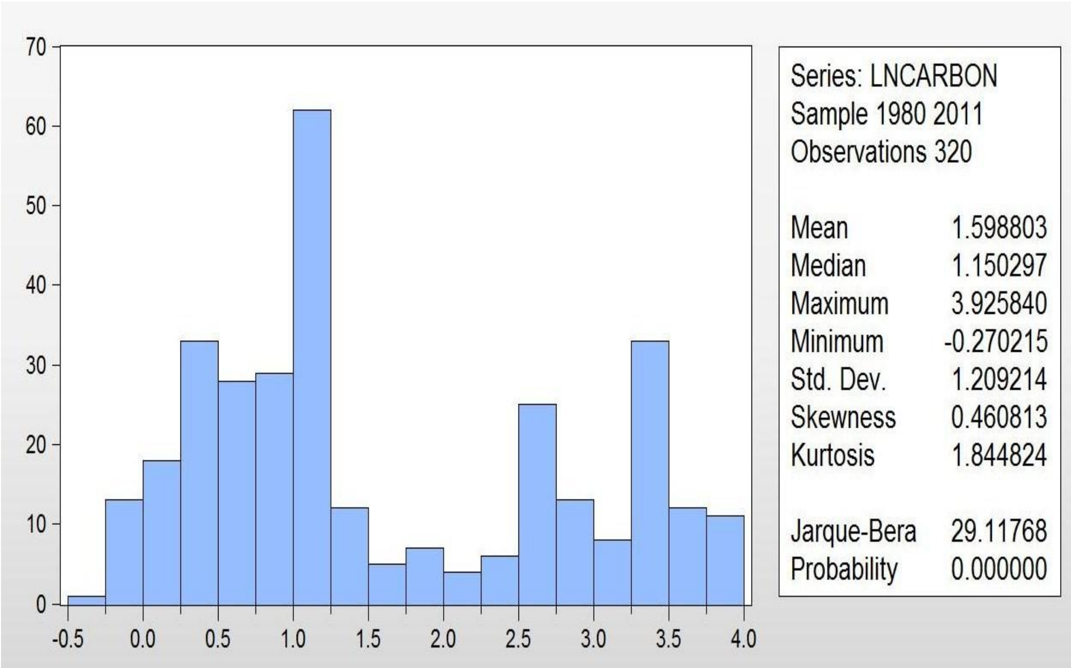

Fig. 44. Statistical Properties of Carbon Emissions Per Capita
Source: Eviews

Additionally, all the series are leptokurtic with a conforming positive kurtosis (3.030 for NGC, 2.196 for GDP, and 1.844 for CO_2).

These results are in accordance with mere visual inspection of the histograms, which show great evidence of high peak around the mean with an extended right tail for both GDP and CO_2 emissions and an extended left tail for natural gas consumption.

In our case, JB is 31.652 for NGC, 16.605 for GDP, and 29.117 for CO_2 associated with a probability of 0; thus implying that we reject the hypothesis of series being normally distributed at all significance levels.

Tables 23, 24 and 25 show a decaying pattern of autocorrelations with a single large spike at lag 1. Since this pattern does not cut to zero, we can say that there exists an autocorrelation between the variables. Our findings are conforming to the probability of the Q statistics that is zero. This further suggests that we can reject the hypothesis of non-autocorrelation.

Table 23. ACF and PACF of Natural Gas Consumption Per Capita

	1	**4**	**8**	**12**	**16**
ADF	0.957	0.842	0.698	0.561	0.416
PACF	0.957	-0.028	0.006	-0.055	-0.041

Table 24. ACF and PACF of GDP Per Capita

	1	**4**	**8**	**12**	**16**
ADF	0.966	0.866	0.738	0.610	0.478
PACF	0.966	-0.019	-0.020	-0.029	-0.021

Table 25. ACF and PACF of Carbon Emissions Per Capita

	1	**4**	**8**	**12**	**16**
ADF	0.967	0.870	0.739	0.607	0.476
PACF	0.967	-0.022	-0.039	-0.046	-0.013

Partial autocorrelation (PAC) is at some points negative, and at others positive. It however lies at a rate very close to zero (statistically insignificant); hence we can presume that there exists a low order of partial autocorrelation.

CHAPTER IV

METHODOLOGY AND EMPIRICAL RESULTS

A. Methodology

This chapter presents the analytical structure behind our empirical modeling procedure. The procedure starts with checking the stationarity of the used variables applying panel root test, latter we move to examine if the variables are cointegrated. Then, we examine the causal relationship ending with some estimation.

1. Panel Unit Root Tests

Increasingly recent literature has looked into panel unit root tests. A number of remarkable investigators such as Levin, Lin and Chu (2002), Breitung (2000), Hadri (1999), and Im, Pesaran and Shin (2003) constructed unit root tests similar to those of individual time series but for panel data models. In fact, those investigators argued that individual unit root tests have limited power relative to panel unit root tests[37]. Investigators also showed that panel unit root tests lead normal distributed statistics whereas unit root tests for a single series have problematical distributions[38]. Testing for unit roots in panel data models is now a standard application and has turned out to be a fundamental part in any time series analysis.

Panel unit root tests will be implemented to check the existence of spurious

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[37] The power of a test is the probability of rejecting the null when it is false.

[38] Baltagi, B. 2001. *Econometric analysis of panel data* (2nd ed.). Chichester, England: John Wiley & Sons.

regressions. There exist numerous panel root tests to examine the stationarity[39] properties of a panel data. Thus, before performing the causality test, it is essential to check for the stationarity of the data used in order to obtain an unbiased estimation from the Granger causality test. In this study, two tests for stationarity of a panel data are applied to test the presence of unit roots, those are Levin et al. test (LLC, 2002) and Im et al. (IPS-W statistic test 2003).

a. <u>Levin, Lin and Chu (LLC 2002) Panel Unit Root Test</u>

In this section we briefly outline LLC test which is one of the most applied tests. Levin, Lin and Chu proposed a test for common unit root test for a panel data model.

Suppose you have N series, and each series has T observations. For each cross-section, carry out an augmented Dickey-Fuller (ADF) regression:

$$\Delta Y_{i,t} = \beta_i Y_{i,t-1} + \gamma_i d_t + \sum_{j=1}^{p_i} \theta_{i,j} \Delta Y_{i,t-j} + \varepsilon_{i,t} \qquad (1)$$

where Δ represents the first difference operator, Y_{it} is the exogenous variable, d_t is a deterministic component such that $d_t = 1$ or $d_t = (1,t)$, ε_{it} is a white noise (WN) disturbance with variance σ^2, p_i is the lag order, $i=1,\dots,N$ denotes cross-section units, and $t=1,\dots,T$ denotes time period.

On the other hand, the test restricts $\tilde{\beta}_i$, the OLS estimate of β_i in equation (1), by keeping it the same across cross-countries. The model in (1) can be written as:

$$\Delta Y_{i,t} = \beta_i Y_{i,t-1} + \gamma_i d_t + \sum_{j=1}^{p_i} \theta_{i,j} \Delta Y_{i,t-j} + \varepsilon_{i,t} \qquad (2)$$

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[39] Stationarity implies that the variables in question have a specific trend and that they revert towards a certain mean.

This means that the autoregressive coefficient ($Y_{i,t-1}$) is assumed to be homogenous across all cross-countries. Thus, the individual progressions are independent across different cross-countries.

The test involves the null hypothesis where all cross-sections in the panel data model have a unit root i.e $H0: \beta1= \beta2=\ldots= \beta N= \beta=0$ against the alternative corresponding to all individual series (Y_{it}) being stationary i.e $H1: \beta1= \beta2=\ldots= \beta N= \beta< 0$.

Because the lag lengths can vary across different cross-sections, for each equation you should carry out a lag length test. The lag order pi could be determined by several methods such as Schwarz Bayesian criterion.

Once the lag order pi is determined for each cross-section, we need to perform 2 auxiliary regressions:

$$\Delta Y_{i,t} = \gamma_i d_t + \sum_{j=1}^{p_i} \theta_{i,j} \Delta Y_{i,t-j} + e_{i,t} \qquad (3)$$

$$Y_{i,t-1} = \gamma_i d_t + \sum_{j=1}^{p_i} \theta_{i,j} \Delta Y_{i,t-j} + v_{i,t-1} \qquad (4)$$

From regressions (3) and (4) we get the following residuals: $\hat{e}_{i,t}$ and $\hat{v}_{i,t-1}$. To control heterogeneity across different units of i, we have to standardize the obtained residuals:

$\tilde{e}_{i,t} = \hat{e}_{i,t} / \hat{\sigma}_{\varepsilon i}$

$\tilde{v}_{i,t-1} = \hat{v}_{i,t-1} / \hat{\sigma}_{\varepsilon i}$

where $\hat{\sigma}_{\varepsilon i}$ is the standard error for each performed ADF for all i.

Finally, we perform the following pooled regression:

$\tilde{e}_{i,t} = \rho\, \tilde{v}_{i,t-1} + \tilde{\varepsilon}_{i,t}$

The test of unit root becomes testing whether $\rho = 0$ or not. The null hypothesis

H0: $\rho = 0$ indicates that all cross-sections of the panel are nonstationary. We can write t statistic as:

$$t\rho = \tilde{\rho} / SE(\tilde{\rho})$$

Besides, the test relies on the assumption that all cross-section units have a unit root or not which is a very restrictive assumption. That is, it rules out intermediate cases where we can have some units with unit roots and others without. Therefore, we have to apply LLC test with another test which allows for heterogeneity across cross-sections to get an accurate result[40].

b. Im, Pesaran and Shin (IPS, 2003) Panel Unit Root Test

Im, Persaran and Shin (IPS, 2003) test is not as restrictive as LLC test in the sense that it allows for heterogeneous coefficients on $Y_{i,t-1}$. The null hypothesis is that each series follow a unit root process i.e H0: $\beta_1 = \beta_2 = \ldots = \beta_N = 0$. Rejection of the null hypothesis means that at least one of the series in the panel is stationary:

$$H1: \begin{cases} \beta_i < 0 & \text{for } i = 1, 2, 3, \ldots, N1 \\ \beta_i = 0 & \text{for } i = N1 + 1, N1 + 2, \ldots, N \end{cases}$$

This means that the portion of the individual time series that are said to be stationary necessitate a nonzero coefficient of $Y_{i,t-1}$ i.e β is less than zero for those series.

The IPS unit root test is based on the mean group approach; the test is based on averaging the individual unit root test statistics. In, Persaran and Shin use the sample mean of the t statistics from equation (1) for each i. Then, the IPS t-bar statistic is defined as the average of the individual ADF statistic allowing different orders of serial

[40] Chen, M. 2013. "Panel unit root and cointegration tests". Department of Finance: National Chung Hsing University.

correlation:

$$\bar{t} = (1/N) \sum_{i=1}^{N} t\beta i$$

where $t\beta i$ is individual t-statistic for testing the null hypothesis H0: $\beta i = 0$ for all i.

Using t-bar statistic, we can construct the statistic Ztbar as:

$$Ztbar = \sqrt{N}\,[\bar{t} - E(\bar{t})] / \sqrt{Var(\bar{t})}$$

where $E(\bar{t})$ and $Var(\bar{t})$ denote the theoretical mean and variance of $\bar{t}$ respectively. We can notice that if the ordinary least square (OLS) estimates of the individual ti were unbiased, then $E(\bar{t}) = 0$. On the other hand, in order to correct for the bias, Monte Carlo simulation can be used to compute $E(\bar{t})$ and $Var(\bar{t})$.

Im, Persaran and Shin showed that Ztbar has as asymptotic standardized normal distribution. We can conclude that rejecting Ztbar =0 is equivalent to rejecting the null hypothesis where each series in the panel contains a unit root. All in all, if the sample average of t statistic is significantly different from zero, at least one of the values of βi is also statistically different from zero[41].

2. Panel Cointegration Tests

Before estimating the relationship between variables of the study and before testing whether there is a causal relationship, we have to determine whether there exists any cointegrating relationship. Similar to panel unit root tests, cointegration tests for panel time series data are of higher power especially with relatively large number of observations.

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[41] Enders, W. 2010. *Applied econometric time series* (3rd ed.). Hoboken, NJ: John Wiley & Sons.

This paper employs two different kinds of recently developed panel cointegration tests: Pedroni's (PP, 2000) test and Kao's (1999) test.

a. <u>Pedroni Test</u>

Pedroni proposed various tests for the null hypothesis of no cointegration between the studied variables in a heterogeneous panel data model. The test allows for considerable cross-sectional interdependence with diverse individual effects. He suggested two types of tests, which are based on the residual and variant of Dickey and Fuller (ADF 1979), Engle and Granger (1987) and Phillips and Perron (PP 1988) cointegration regressions[42]. The test employs four panel statistics, which are based on within dimension approach and three group panel statistics, which are based on between dimension approaches.

In case of panel statistics, the four tests are based on pooling the autoregressive coefficients associated with unit root tests of residuals for each section of the panel. Moreover, the first autoregressive parameter in this case is assumed to be the same across the different members of the panel. The panel statistics include: panel v-statistics, panel ρ-statistics, panel PP-statistics and panel ADF-statistics. In case of group panel statistics, the three tests are based on the average of individual autoregressive coefficients across the different cross-sections of unit root tests on the estimated residual. Unlike panel statistics case, group panel statistics allows the autoregressive parameter to vary over different sections of the panel used. The group panel statistics include: group panel ρ-statistics, group panel PP-statistics and group panel ADF-statistics.

Pedroni has set all the seven statistics are distributed asymptotically as standard

[42] Baltagi 2001.

normal variables. All theses' statistics also depend on the average individually estimated coefficients for each section included in the panel. The tests provide accommodation for individual specific short run dynamics, individual specific slope coefficients and individual specific fixed effects and deterministic trends that are introduced to capture common disturbances across all sections included.

We can say that cointegration among variables examined exist for all sectors in case the null hypothesis is rejected for panel statistics. On the other hand, if the null hypothesis is rejected for group panel statistics, then the variables are cointegrated for at least one section of the panel.

b. Kao Test

Kao constructed two types of panel cointegration tests, the ADF and DF residual cointegration tests. In this study, we are going to use the cointegration test based on ADF test.

Consider the following panel regression model:

$$Y_{i,t} = \alpha_i + \beta X_{i,t} + \varepsilon_{i,t}$$

where $t = 1, ..., T$ and $i = 1, ..., N$ as well as $Y_{i,t} = Y_{i,t-1} + e_{i,t}$ and $X_{i,t} = X_{i,t-1} + v_{i,t}$.

The Kao test only allows for individual intercept α_i which is heterogeneous across cross-sections of the panel.

The ADF type test can be calculated from the estimated residuals:

$$\varepsilon_{i,t} = \rho \tilde{\varepsilon}_{i,t-1} + \sum_{j=1}^{p} \theta_j \Delta \tilde{\varepsilon}_{i,t-j} + u_{i,t,p} \quad (5)$$

where ρ is chosen when $u_{i,t,p}$ series is not correlated under the null hypothesis of no cointegration i.e $H0: \rho = 0$.

Then the ADF statistics, which converges to a standard normal distribution using sequential limit theory can be computed as[43]:

$$ADF = \frac{tADF + [\sqrt{(6 N \tilde{\sigma}u)} / 2\tilde{\sigma}0u]}{\sqrt{[(\tilde{\sigma}^2 0u / 2\tilde{\sigma}^2 u) + (3\tilde{\sigma}^2 u / 10\tilde{\sigma}^2 0u)]}}$$

where tADF is the t statistic of ρ in equation (5) and σ0u comes from the covariance matrix $\omega = \begin{pmatrix} \sigma^2 0e & \sigma 0ev \\ \sigma 0ve & \sigma^2 0v \end{pmatrix}$ of the bivariate process (vi,t , ei,t).

3. Panel Causality Analysis

Consider the following regression:

$$Y_{i,t} = \alpha_i + \beta_i X_{i,t} + \rho_i Z_{i,t} + \varepsilon_{i,t} \quad (6)$$

To examine the long run and short run causal relationship a panel vector error correction model (VECM) followed by Engle and Granger two-step procedure (1987) is employed. The first step estimates the long run model specified in equation (6) to find the estimated residuals corresponding to the deviation from equilibrium. The second step obtains the estimated coefficients related to short run. Defining the lagged residuals from equation (6) as the error correction term, the following equations are used in conjunction with panel Granger causality testing:

$$\Delta Y_{i,t} = \theta_{1,i} + \sum_{k=1}^{m} \theta_{1,1,i,k} \Delta Y_{i,t-k} + \sum_{k=1}^{m} \theta_{1,2,i,k} \Delta X_{i,t-k} + \sum_{k=1}^{m} \theta_{1,3,i,k} \Delta Z_{i,t-k} + \lambda_{1,i} ECT_{i,t-1} + u_{1,i,t} \quad (7)$$

$$\Delta X_{i,t} = \theta_{2,i} + \sum_{k=1}^{m} \theta_{2,1,i,k} \Delta Y_{i,t-k} + \sum_{k=1}^{m} \theta_{2,2,i,k} \Delta X_{i,t-k} + \sum_{k=1}^{m} \theta_{2,3,i,k} \Delta Z_{i,t-k} + \lambda_{2,i} ECT_{i,t-1} + u_{2,i,t} \quad (8)$$

[43] Baltagi 2001.

$$\Delta Z_{i,t} = \theta_{3,i} + \sum_{k=1}^{m} \theta_{3,1,i,k} \Delta Y_{i,t-k} + \sum_{k=1}^{m} \theta_{3,2,i,k} \Delta X_{i,t-k} + \sum_{k=1}^{m} \theta_{3,3,i,k} \Delta Z_{i,t-k} + \lambda_{3,i} ECT_{i,t-1} + u_{3,i,t} \quad (9)$$

where i (i= 1, 2, …, N) represents number of cross sections used; t (i= 1, 2, …, T) proxies the time period of the panel; Δ denotes first difference operator; $\theta_{j,i,t}$ for j= 1, 2, 3 proxies the fixed effect; k (k= 1, …, m) represents the optimal lag order set by Schwarz Information Criterion (SIC); as well as $ECT_{i,t-1}$ indicates the estimated lagged error correction term derived from the long run cointegrating relationship of equation (6) in which $ECT_{i,t} = Y_{i,t} - \tilde{\beta}_i X_{i,t} - \tilde{\rho}_i Z_{i,t}$. All the error correction vectors are estimated with the same lag structure that is determined in unrestricted vector autoregression (VAR) framework. In addition, The term $\lambda_{j,i}$ for j= 1, 2, 3 represents the adjustment and coefficient and $u_{j,i,t}$ is the disturbance term which is assumed to be uncorrelated with mean of zero[44].

The causal relationship can be determined by testing the significance of the coefficients of the dependent variables in equations (7), (8) and (9). For short run causality, we check whether $\theta_{1,2,i,k} = 0$ and $\theta_{1,3,i,k} = 0$ for all i and k in equation (7), $\theta_{2,1,i,k} = 0$ and $\theta_{2,3,i,k} = 0$ for all i and k in equation (8) or $\theta_{3,1,i,k} = 0$ and $\theta_{3,2,i,k} = 0$ for all i and k in equation (9). Then, we check the long run causality through the significance of the speed of adjustment. The significance of the coefficient of the error correction term identifies the long run relationship in the cointegrated process. For long run causality, we check whether $\lambda_{1,i} = 0$ for all i in equation (7), $\lambda_{2,i} = 0$ for all i in equation (8) or $\lambda_{3,i} = 0$ for all i in equation (9). Due to the fact that all the variables in the model are used in their stationary form, we can use the standard F-statistic for the

[44] Ben Rajab, J. and Farhani, S. (2012). “Link between Economic Growth and Energy Consumption in Over 90 Countries”. *Interdisciplinary Journal of Contemporary Research in Business* 11(3).

test.

4. Panel FMOLS and DOLS Estimates

The estimators of ordinary least squares (OLS) regressions when applied to cointegrated panels are significantly convergent, yet their asymptotic distribution is biased, inconsistent and depends on nuisance parameters that are serially correlated. These problems which affect individual time series data also exists for panel data case even with the presence of heterogeneity. Econometricians suggested more powerful tests that examine the condition on cointegrating vector, which is necessary for strong relation to hold and eliminate problems caused by long run correlation between cointegrating equation and stochastic regressors. To perform tests on cointegrated vectors, it is required to employ techniques of effective estimation. These methods agree to pose the null hypothesis in a more natural way in order to study if strong relationship between relevant variables holds consistently for all sections of the panel. The long run cointegration vector could be tested by several methods such as "group mean" panel Fully Modified Ordinary Least squares (FMOLS) by Phillips and Hansen (1990) and Pedroni (2000) as well as panel Dynamic Ordinary Least squares (DOLS) by Stock and Watson (1993) and Kao and Chiang (2000). According to Kao and Chiang (2000) the methods of FMOLS and DOLS are proved to give normally distributed estimators. The panel FMOLS and DOLS estimators allow correcting standard OLS for bias induced by endogeneity and serial correlation. Panel DOLS is fully parametric and presents a computationally substitute to the panel FMOLS[45]. Estimators of FMOLS show signs of small sample biasness whereas estimators of DOLS have better sample properties that

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[45] Kao, C., & Chiang, M. (2000). "On the estimation of a cointegrated regression in panel data". *Elsevier Science Inc.* 15: 179-222.

allow it to outperform those of OLS and FMOLS[46]. Thus, we use FMOLS and DOLS to estimate the long run relationship between the variables.

The following empirical model is based on the regression between the three relevant variables as shown in equation (6), where Y and X slopes βi with as well as Y and Z slopes ρi, which may or may not be homogeneous across i:

$$Y_{i,t} = \alpha_i + \beta_i X_{i,t} + \rho_i Z_{i,t} + \sum_{j=-k1}^{k2} \Phi_{i,j} \Delta X_{i,t-j} + \sum_{j=-k1}^{k2} \varphi_{i,j} \Delta Z_{i,t-j} + \varepsilon_{i,t}$$

where i (i= 1, …, N) denotes number of cross sections in the panel, t (t= 1, …, T) denotes the time period, k1 is the maximum lag length, and k2 is the maximum lead length.

B. Empirical Results

1. Panel Unit Root Tests

In the first step in our empirical analysis, it is essential to figure out the integration properties of the data series in panel form. Levin, Lin and Chu (LLC 2002) and Im, Pesaran and Shin (IPS 2003) unit root tests were undertaken to examine the unit root properties of the variables employed with their natural logarithmic form. We estimate two models: one without time trend and one with time trend. The results of these tests are reported in Tables 26 and 27.

In Table 26, Im, Pesaran and Shin unit root test with trend and intercept and Levin, Lin and Chu unit root test with intercept as well as intercept and trend, the null of stationarity of the logarithm of natural gas consumption and the logarithm of carbon dioxide emissions is rejected at 1% significance level. On the other hand, the results of

[46] Farhani, S. and Shahbaz, M. (2013). "The role of natural gas consumption and trade in Tunisia's output". *Energy Policy* 66.

the unit root test with intercept suggest that for IPS panel unit root test, at the 5% and 1% significance levels, the logarithm of natural gas consumption, the logarithm of economic growth and the logarithm of carbon dioxide emissions are non stationary for the panel. For the three variables, the null hypothesis of a unit root cannot be rejected at these levels.

Table 26. Panel Unit Root Results (Level)

	LNNGC		**LNGDP**		**LNCarbon**	
Test	**Statistic**	**Probability**	**Statistic**	**Probability**	**Statistic**	**Probability**
IPS: (C)	-3.123	0.001	2.784	0.993	0.126	0.550
IPS: (C+T)	-3.334*	0.0004	0.454	0.675	-3.677*	0.000
LLC: (C)	-4.083*	0.000	0.745	0.772	-0.762	0.223
LLC: (C+T)	-3.288	0.0005	-0.217	0.414	-4.289*	0.000

Table 27. Panel Unit Root Results (First Difference Level)

	Δ(LNNGC)		**Δ(LNGDP)**		**Δ(LNCarbon)**	
Test	**Statistic**	**Probability**	**Statistic**	**Probability**	**Statistic**	**Probability**
IPS: (C)	-12.753*	0.000	-11.436*	0.000	-12.992*	0.000
IPS: (C+T)	-12.470*	0.000	-10.425*	0.000	-13.928*	0.000
LLC: (C)	-12.904*	0.000	-10.312*	0.000	-14.494*	0.000
LLC: (C+T)	-8.563*	0.000	-9.045*	0.000	-13.656*	0.000

Notes: C denotes the existence of intercept only and C+T denotes the existence of intercept and trend in the respective unit root tests. LLC and IPS examine the null hypothesis of nonstationarity. The tests assume asymptotic normality distribution. The optimal lag length was selected automatically using the Schwarz criterion. (*) denotes statistical significance at the 1% level. All variables are in natural logarithms (LN).

Table 27 shows the results of the selected panel unit root tests carried out on the series in first differences. The goal of this procedure is to prove the appearance of additional unit root and determine the order of integration of each series. We are able to reject the null hypothesis at the conventional levels of significance for all variables when we perform the test on the first difference of the variable. Then, the results show that first difference series are stationary. From theses' findings, we conclude that the variables in levels are integrated by order of one which means that the variables are I(1).

2. Panel Cointegration Tests

Having established that the three variables (LNNGC, LNGDP and LNCarbon) are integrated or order one; they contain a panel unit root, we continue to test whether there exists a long run relationship between the three variables. In this section, we use panel cointegration tests recommended by Pedroni and Kao.

Table 28 reports the results of Pedroni's panel cointegration test. Note that the logarithm of natural gas consumption is taken as the dependent variable. Except for the panel υ-stat, panel ρ-stat and group ρ-stat, all other statistics significantly reject the null of no cointegration. In general, we obtain a strong evidence of integration among these series. Besides, Kao's residual cointegration tests are presented in Table 29.

Table 28. Pedroni's residual cointegration test results (LNNGC as dependent variable)

Method	**Test Statistic**	**Probability**
Within Dimension		
Panel υ-stat	-0.710	0.761
Panel ρ-stat	-0.888	0.187
Panel PP-stat	-3.002*	0.001
Panel ADF-stat	-3.161*	0.001
Between Dimension		
Group r-stat	-0.942	0.173
Group PP-stat	-8.880*	0.000
Group ADF-stat	-7.003*	0.000

Notes: The panel cointegration test includes intercept and time trend. The null hypothesis is that the variables are not cointegrated. Under the null tests, all statistics are distributed as standard normal. (*) denotes the significance at 5% significance level.

Table 29. Kao's residual cointegration test results (LNNGC as dependent variable)

	t-statistic	Probability
ADF	-4.292*	0.000

Notes: The null hypothesis is that the variables are not cointegrated. (*) denotes the significance at 5% significance level.

According to Table 29, we reject the null hypothesis of no cointegration relationship between natural gas consumption per capita, economic growth per capita and per capita carbon dioxide emissions at the 5% significance level. All in all, it can be predicted that NGC, GDP and CO_2 emissions move together in the long run. We can conclude that there is a long run steady state relationship between the three variables for a cross section of MENA countries after permitting country specific effects.

3. Panel Causality Test

Table 30 reports the results of the panel causality tests among the three variables. In the GDP equation, it is shown that NGC and CO_2 emissions are insignificant at the 5% level of significance in short run dynamics, yet statistics are empirically significant in long run dynamics. Furthermore, because the ECT associated with joint tests of NGC and CO_2 in the GDP equation are significant. The variables indicate the essential function of GDP. Thus, economic growth could play an important adjustment factor as the system departs from the long run equilibrium. This result illustrates that economic growth is determined by natural gas consumption supporting the growth hypothesis. As shown in Table 30, we cannot find evidence of short run causality running from LNGDP and LNCarbon to LNNGC. In accordance with this result, natural gas consumption will be affected by neither economic development nor carbon release. Consequently, if empirical findings show that the cointegrated relationships vanish, then natural gas use has no influence on domestic output temporarily. As a result, in the long run, this unidirectional causality reveal that gas conservation policies may be applied but with impermanent influence on output. We can say that gas serves as an engine fastening development. It is noteworthy that in the natural gas use equation, GDP and carbon emissions are not significant at 5% level showing that there is neither long run nor short run causal relationship running from GDP to NGC.

Table 30. Panel Causality Test Results

Dependent Variable			**ΔLNNGC**	**ΔLNGDP**	**ΔLNCarbon**
Sources of Causation (Independent Variable)	Short Run	ΔLNNGC	---	0.435 (0.510)	1.352 (0.246)
		ΔLNGDP	7.83E-11 (1.000)	---	1.837 (0.176)
		ΔLNCarbon	0.242 (0.623)	0.483 (0.488)	---
	Long Run	ECT (t-stat)	0.0008 (0.419)	4.769* (0.000)	0.0002 (0.575)
		Joint (ECT and ΔLNNGC)	---	11.704* (0.000)	0.864 (0.422)
		Joint (ECT and ΔLNGDP)	0.097 (0.907)	---	1.466 (0.233)
		Joint (ECT and ΔLNCarbon)	0.202 (0.817)	11.728* (0.000)	---

Notes: Figures denote F-statistic values. P-values are in parentheses. ECT represents the estimated error correction term. (*) indicates statistical significance at the 5% level.

4. Panel FMOLS and DOLS Estimations

Having found a cointegrating relationship between per capita natural gas consumption, economic growth and carbon dioxide emissions per capita, in this section we estimate the long run parameters of the model. To achieve this as explained earlier, a long run relationship is determined using FMOLS and DOLS techniques for heterogeneous cointegrated panels and individual countries.

Table 31 reports the long run coefficients from individual and panel FMOLS, DOLS and OLS tests where the dependent variable is natural gas consumption per capita. The results of Table 31 help us in distinguishing whether natural gas consumption and carbon dioxide emissions stimulate economic growth in the selected MENA countries or not. Individual estimates and the respective t-statistics for H0: βi= 0 are provided in the table associated with results of panel estimates at the bottom of the table.

Table 31. FMOLS and DOLS estimates for MENA countries

Country	**FMOLS**		**DOLS**	
	LNNGC	**LNCarbon**	**LNNGC**	**LNCarbon**
Algeria	-0.984* (-3.647)	1.218* (3.505)	1.907* (2.028)	-1.562* (-2.018)
Bahrain	1.830 (1.805)	-2.110 (-1.687)	2.881 (1.972)	-3.095 (-1.551)
Egypt	0.185 (1.405)	0.251 (0.526)	0.150 (1.580)	0.765* (2.177)
Jordan	0.193* (8.028)	-0.292 (-0.893)	0.199* (7.442)	-0.234 (-0.566)
Morocco	0.074* (3.144)	1.052* (9.078)	0.082* (2.682)	1.077* (8.071)
Oman	-0.034 (-0.203)	0.507* (2.423)	-0.520 (-1.712)	1.125* (2.890)
Saudi Arabia	-0.223* (-5.812)	1.365* (12.023)	-0.156 (-1.005)	1.038* (3.713)
Tunisia	0.012 (0.048)	1.484 (1.727)	0.410 (1.503)	0.125 (0.143)
Turkey	-0.032* (-3.106)	1.052* (13.877)	-0.017 (-1.418)	1.007* (12.450)
UAE	-0.655* (-6.653)	1.034* (5,306)	-0.544 (-1.430)	1.048* (2.403)
Panel	0.048* (2.129)	0.586* (6.923)	0.091* (3.793)	0.503* (7.237)

Notes: LNNGC is considered as the dependent variable. t-statistics are given in parentheses. Asymptotic distribution of t-statistic is standard normal as T and N go to infinity. (*) denotes that the estimated parameters are significant at the 5% level. All variables are in natural logarithmic form.

Table 31 reports the long run coefficients from panel FMOLS, DOLS and OLS tests where the dependent variable is natural gas consumption per capita. For panel test, FMOLS and DOLS estimators generate similar outcomes regarding sign and statistical significance, yet the magnitudes of the estimated elasticities are faintly different. All the coefficients of per capita GDP and carbon dioxide emissions per capita are statistically significant at the 5% level, and the effect is positive using the three estimation techniques. Implicit here is that a 1% increase in per capita NGC leads to increase in GDP per capita by 0.05% using FMOLS and 0.1% using DOLS technique. On the other hand, a 1% increase in carbon dioxide emissions per capita leads to increase in per capita GDP by 0.5% using DOLS and almost 0.6% using FMOLS estimation procedure. Table 5 indicates that natural gas use and carbon emissions have a positive effect on GDP, which means that an increase in gas demand or carbon emissions raises the economic development. On a per country basis, NGC has a significantly positive effect on GDP except for Oman, Saudi Arabia, Turkey and UAE. All in all, the individual and panel results provide clear evidence that there exists a causal relationship between per capita natural gas consumption, economic growth and carbon dioxide emissions in our sample of MENA economies.

CHAPTER V

CONCLUSION

The causal relationship between natural gas consumption, economic development and carbon dioxide release is an extensively studied issue, yet the empirical findings are conflicting regarding the direction of the causality. The purpose of this study was to analyze the dynamic linkage between natural gas use, economic income and carbon dioxide emissions in 10 MENA countries over the period 1980-2011. We employed in this study the panel unit root tests, panel cointegration tests and panel causality test. Our panel cointegration test results demonstrate that natural gas use, economic income and carbon emissions are cointegrated for the whole panel of countries. It means that the three variables move together in long run. Moreover, to examine this causal relationship we employed Engle and Granger test which checks both long run and short run dynamic linkage. In sum, natural gas consumption and carbon emissions have a positive and statistically significant impact on GDP in the long run. In other words, gas is an essential factor for economic development in long run dynamics. On the other hand, there is neither short run nor long run causal relationship running from GDP to NGC. This means that changes in gas use could affect the economic activity in the MENA region, but not vice versa. Thus, economic growth is basically stimulated by continuous natural gas utilization. This relationship provides useful information to policy makers in these countries for designing appropriate energy policies. Although gas conservation policies may be easily implemented, it will compromise domestic income. In order to avoid negative shocks to economic growth, authorities in MENA region should implement well planned long term gas policy and focus on investments in gas infrastructure to boost gas efficiency.

BIBLOGRAPHY

Adhikari, D. and Chen, Y. (2012). "Energy consumption and economic growth: A panel cointegration analysis for developing countries". *Review of Economics and Finance.*

Adjaye, J. (2000). "The relationship between energy consumption, energy prices and economic growth: Time series evidence from Asian developing countries". *Energy Economics* 22: 615-625.

Ahmad, N., Hamad, M., Hayat, N. and Luqman, M. (2012). "Energy consumption and economic growth: Evidence from Pakistan'. *Australian Journal of Business and Management Research* 2(6).

Altinay, G. and Karagol, E. (2004). "Structural break, unit root, and causality between energy consumption and GDP in Turkey". *Energy Economics* 26(6): 985-994.

Amroabadi, B., Jafari, S., Mahmoudinia, D. and Pourshahabi, F. (2013). "Oil products consumption, electricity consumption-economic growth nexus in the economy of Iran: A bound testing cointegration approach". *International Journal of Academic Research in Business and Social Sciences* 3(1): 353-367.

Apergis, N. and Payne, J. (2010). "Natural gas consumption and economic growth: A panel investigation of 67 countries". *Applied Energy* 87: 2759-2763.

Asalan, A., Kum, H. and Ocal, O. (2012). "The relationship among natural gas consumption, capital and economic growth: Bootstrap-Corrected causality tests from G-7 countries". *Renewable and Sustainable Energy Reviews* 16(5): 2361-2365.

Baltagi, B. 2001. *Econometric analysis of panel data* (2nd ed.). Chichester, England: John Wiley and Sons.

Belke, A., Dreger, C. and Haan, F. 2010. "Energy consumption and economic growth: New insights into the cointegration relationship". RUHR Economic Papers, 190.

Belloumi, M. (2009). "Energy consumption and GDP in Tunisia: Cointegration and causality analysis". *Energy Policy* 37(7): 2745-2753.

Ben Rajab, J. and Farhani, S. (2012). "Link between Economic Growth and Energy Consumption in Over 90 Countries". *Interdisciplinary Journal of Contemporary Research in Business* 11(3).

Bhattacharyya, S. 2011. *Energy economics: Concepts, issues, markets and governance*. London, England: Springer.

Binh, P. (2011). “Energy consumption and economic growth in Vietnam: Threshold cointegration and causality analysis”. *International Journal of Energy Economics and Policy* 1(1): 1-17.

Bowden, N. and Payne J. (2008). “The causal relationship between US energy consumption and output: A disaggregated analysis”. *Journal of Policy Modeling* 31: 180-188.

BP Statistical Review of World Energy. 2012; available from http://www.bp.com/statisticalreview; Internet; accessed 29 January 2014.

Campo, J. and Sarmiento, V. (2013). “The relationship between energy consumption and GDP: Evidence from a panel of 10 Latin American countries”. *Latin American Journal of Economics* 50(2).

Chang, C.P., Chen, P.F. and Lee, C.C. (2008). “Energy-Income causality in OECD countries revisited: The Key Role of Capital Stock”. *Energy Economics* 30(5): 2359-2373.

Chen, M. 2013. “Panel unit root and cointegration tests”. Department of Finance: National Chung Hsing University.

Choi, J.Y. and Yu, E.S.H. (1985). “The causal relationship between energy and GNP: An international comparison”. *Journal of Energy and Development* 10(2): 249-272.

Cifter, A. and Ozun, A. (2007). “Multi-Scale causality between energy consumption and output growth in emerging markets: Evidence from Turkey”. *Investment Management and Financial Innovations* 4(2): 60-70.

El-Sakka, M.I.T. and Ghali, K.H. (2004). “Energy use and output growth in Canada: A multivariate cointegration approach”. *Energy Economics* 26(2): 225-238.

Enders, W. 2010. *Applied econometric time series* (3rd ed.). Hoboken, NJ: John Wiley and Sons.

Energy Delta Institute; available from: http://www.energydelta.org; Internet; accessed 29 January 2014.

Farhani, S. and Shahbaz, M. (2013). “The role of natural gas consumption and trade in Tunisia's output”. *Energy Policy* 66.

Glasure, Y. and Lee, A. (1998). “Cointegration, error-correction, and the relationship between GDP and energy. The case of South Korea and Singapore”. *Resource and Energy Economics* 20(1): 17-25.

*global*EDGE, Michigan State University; available from http://www.globaledge.msu.edu; Internet; accessed 11 February 2014.

Halicioglue, F. (2009). “An econometric study of CO_2 emissions, energy consumption, income and foreign trade in Turkey”. *Energy Policy* 37(3): 1156-1164.

Hossain, M. and Saeki, C. (2012). “A dynamic causality study between electricity consumption and economic growth for global panel: Evidence from 76 countries”. *Asian Economic and Social Society* 2(1): 1-13.

Jobert, T. and Karanfil, F. (2007). “Sectoral energy consumption by source and economic growth in Turkey”. *Energy Policy* 35: 5447-5456.

Kalyoncu, H., Gürsoy, F. and Göcen, H. (2013). “Causality relationship between GDP and energy consumption in Georgia, Azerbaijan and Armenia”. *International Journal of Energy Economics and Policy* 3(1): 111-117.

Kang, J.G, Yuan, J.H. and Zhao C.H. (2008). “Energy consumption and economic growth: Evidence from China at both aggregated and disaggregated levels”. *Energy Economics* 30(6): 3077-3094.

Kao, C. and Chiang, M. (2000). “On the estimation of a cointegrated regression in panel data”. *Elsevier Science Inc.* 15: 179-222.

Kourbali, B. and Eddrief-Cherfi, S. (2012). “Energy consumption and economic growth in Algeria: Cointegration and causality analysis”. *International Journal of Energy Economics and Policy* 2(4): 238-249.

Lean, H.H. and Smyth, R. (2010). “Multivariate granger causality between electricity generation, exports, prices and GDP in Malaysia”. *Energy* 35(9): 3640-3648.

Lee, C. and Chang, C. (2005). “Energy consumption and economic growth in Asian economies: A more comprehensive analysis using panel data”. *Resource and Energy Economics* 30: 50-65.

Lee, C. and Lee, J. (2010). “A panel analysis of the demand for total energy and electricity in OECD countries”. *The Energy Journal* 31(11).

Mallick, H. (2009). “Examining the linkage between energy consumption and economic growth in India”. *The Journal of Developing Areas* 43(1): 249-280.

Narayan, P. and Smyth, R. (2009). “Multivariate granger causality between electricity consumption, exports and GDP: Evidence from a panel of Middle Eastern countries”. *Energy Policy* 37(1): 229-236.

Ozturk, I. and Acaravci, A. (2010). “CO_2 emissions, energy consumption and economic growth in Turkey”. *Renewable and Sustainable Energy Reviews* 14: 3220-3225.

Payne, J.E. (2010). “Survey of the international evidence on the causal relationship between energy consumption and growth”. *Journal of Economic Studies* 37(1): 53-95.

Payne, J.E. (2011). “US disaggregate fossil fuel consumption and real GDP: An empirical note”. Energy Sources Part B: *Economies, Planning, and Policy* 6(1): 63-68.

Ratner, M. (2010). “Global natural gas: A growing resource”. *Congressional Research* R41543.

Shahbaz, M., Farhani, S. and Rahman, M. 2013. “Natural gas consumption and economic growth nexus: The role of exports, capital and labor in France”. MPRA Paper, 50619.

Soytas, U. and Sari, R. (2003). “Energy consumption and GDP: causality relationship in G-7 countries and emerging markets”. *Energy Economics* 25: 33-37.

Tan, E.C. and Tang, C.H. (2012). “Electricity consumption and economic growth in Portugal: Evidence from a multivariate framework analysis”. *The Energy Journal* 33(4): 23-48.

The Climate Institute; available from http://www.climate.org; Internet; accessed 5 April, 2014.

UN. *Framework Convention on Climate Change*. United Nations; available from: http://unfccc.com; Internet; accessed 20 March 2014.

US Energy Information Administration; available from http://www.eia.gov; Internet; accessed 3 February, 2014.