Economics of Natural Gas Exports from Libya to Europe

Mariam Mohamed Alkawfi

Submitted to the
Institute of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
in
Economics

Eastern Mediterranean University
August 2019
Gazimağusa, North Cyprus

Approval of the Institute of Graduate Studies and Research

Prof. Dr. Ali Hakan Ulusoy
Acting Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Doctor of Philosophy in Economics.

Prof. Dr. Mehmet Balcılar
Chair, Department of Economics

We certify that we have read this thesis and that in our opinion it is fully adequate in scope and quality as a thesis for the degree of Doctor of Philosophy in Economics.

Prof. Dr. Glenn Paul Jenkins
Co-Supervisor

Prof. Dr. Sevin Uğural
Supervisor

Examining Committee

1. Prof. Dr. Hakan Kahyaoğlu
2. Prof. Dr. Nevzat Şimşek
3. Prof. Dr. Sevin Uğural
4. Assoc. Prof. Dr. Çağay Coşkuner
5. Assoc. Prof. Dr. Hasan Güngör

ABSTRACT

In addition to being the holder of Africa's largest proved crude oil reserves, Libya is a significant holder of natural gas reserves as well having the fifth largest proved reserves. Libyan proved reserves of natural gas are about 55 trillion cubic feet (tcf), although the period between 2004 and 2015 witnessed a dramatic increase in production of natural gas, the reserves remain stable during last decade. With reserves to production ratio above 100, Libya has the ability to produce gas not less than 100 years with output level of 10 bcm with potential to double this production Mac Donald M.(2010) and Hanfer and Tagliapietra (2013). Libya has a significant potential to be a strategic supplier as compared to other natural gas suppliers to Europe in the Mediterranean region. In order to obtain a sustainable low-carbon economy, European Union countries are moving away from gasoline and diesel with high CO2 emissions towards efficient energy sources such as natural gas and renewable energy. The replacement of natural gas for coal and petroleum is reducing emissions of carbon (C2ES, 2013).

In this study, we tested CO_2 emissions convergence in EU countries and EKC in Italy. Also, we conducted a financial assessment of the natural gas pipeline project in Libya. Our findings refer to evidence of convergence in CO_2 emissions, with absence of inverted U-shaped relationship in both EU countries and Italy. In addition, our financial analysis results show the capability for Libya to increase gas production and its potential to meet the demand in Europe by the developed natural gas pipeline.

Keywords: Bahr Essalam, CBA, CO_2 emissions, EKC, EU, natural gas pipeline, Libya , Italy

ÖZ

Afrika'nın kanıtlanmış en büyük ham petrol rezervine sahip olmasının yanı sıra, Libya, kanıtlanmış en büyük beşinci doğal gaz rezervine sahiptir. Bu çalışma, doğal gaz boru hattı için fizibilite çalışması kullanarak Libya'nın doğal gaz piyasasında önemli bir rol oynama yeteneğini incelemeye çalışmaktadır. Libya'nın doğal gaz rezervlerinin yaklaşık 55 trilyon fit küp (tcf) olduğunu bilinmektedir. 2004 ve 2015 arasındaki dönemi, doğal gaz üretiminde çarpıcı bir artışa tanık olmasına rağmen, rezervler son on yılda sabit kalmıştır. 100'ün üzerindeki üretim oranına sahip rezervler ile Libya, Mac Donald M. (2010) ve Hanfer ve Tagliapietra (2013) göre bu üretimi ikiye katlama potansiyeli olan 10 bcm'lik üretim seviyesi ile 100 yıldan az olmamak üzere gaz üretme kabiliyetine sahiptir. Libya, Akdeniz bölgesindeki Avrupa'daki diğer doğal gaz tedarikçileri ile karşılaştırıldığında stratejik bir tedarikçi olma potansiyeline sahiptir. Sürdürülebilir düşük karbonlu bir ekonomi elde etmek için, Avrupa Birliği ülkeleri doğal gaz ve yenilenebilir enerji gibi verimli enerji kaynaklarına doğru yüksek CO_2 emisyonlu benzin ve dizelden uzaklaşmaktadır. Kömür ve petrol için doğal gazın değiştirilmesi, karbon emisyonlarını azaltmaktadır (C2ES, 2013).

Bu çalışmada, AB ülkelerinde CO_2 salınımını ve İtalya'da EKC'yi test ettik. Ayrıca, Libya'daki doğal gaz boru hattı projesinin finansal bir değerlendirmesini yaptık. Bulgularımız, hem AB ülkelerinde hem de İtalya'da ters U şeklinde bir ilişki olmadığı için CO_2 emisyonlarında yakınsama kanıtlarına işaret ediyor. Ek olarak, finansal analiz sonuçlarımız Libya'nın doğalgaz boru hattı ile doğalgaz üretimini artırma ve Avrupa'daki talebi karşılama potansiyelini göstermektedir.

Anahtar Kelimeler: EKC, CBA, CO_2 emisyonları, doğal gaz boru hattı, Bahr Essalam, Libya, AB, İtalya

DEDICATION

To

My Beloved Family

☺

ACKNOWLEDGMENT

I would like to thank Prof. Dr. Sevin Ugural and Prof. Dr. Glenn Jenkins for their supervision, advice, guidance and support throughout the work that enrich my growth as a student.

I also would like to record my gratitude to Prof. Dr. Mehmet Balcilar for his ideas and support that inspired me in my research.

Special thanks to Prof. Dr. Mohamed Buzakuk for his constant encouragement and faith in me, I am indebted to him more than he knows. And my thanks and appreciation to my friends Ezgi Bertiz and Sadek El Faituri (LSS) for their support in various ways at the most needed time.

Last but not least I am grateful to my family for their patience, support and prayers all the time.

TABLE OF CONTENTS

ABSTRACT i

ÖZ iv

DEDICATION vi

ACKNOWLEDGMENT……………………………..………………………vii

LIST OF TABLES xi

LIST OF FIGURES xiii

1 INTRODUCTION………………………………………………………….1

2 LITETEAURE REVIEW…………………...……………………………….8

2.1 Convergence of CO_2 emissions…...…………………………….………….8

2.2 Envirnmental Kuznets Curve test (EKC)...12

2.3 Economics of Libyan Natural Gas 17

3 NATURAL GAS DEMAND IN EUROPEAN UNION.................................... 21

3.1 General overview on natural gas market 23

3.2 The Environmental concerns: CO_2 Emissions in EU Countries 26

3.2.1 CO_2 Emissions convergence: Literature review 26

3.2.2 Trend of CO_2 Emissions over the Period of the Study: A Graphical Analysis 27

3.3 Natural gas demand in Italy 30

3.4 Environmental policy in Italy.. 31

3.5 The Importance of Natural Gas Trade from Libya 37

4 AN OVERVIEW OF LIBYAN ECONOMY AND GAS INDUSTRY 40

4.1 Libyan Economy-General overview 41

4.2 Energy Sector in Libya... 43

4.2.1 Libya's energy consumption 44
4.2.2 Libya and the Natural Gas Market 45
4.2.3 Production of natural gas 47
4.2.4 Proved Natural Gas Reserves 47
4.3 Liquefied Natural Gas (LNG) 51
4.4 The Importance of Libyan Natural Gas to Europe 52
4.5 Italy as a Hub for Energy to Europe 52
4.5.1 Natural Gas in Italy 54
4.6 Libyan and Italian Energy Partnership 55
4.6.1 Main Libyan Projects to export Natural gas to Italy 57
4.7 The potential and the challenges: Current and prospective view 58
4.7.1 The Impact of International Sanctions 61
4.7.2 The political instability in Libya and economy development 62
4.7.3 Environmental Issues 64
5 METHODOLOGY 66
5.1 Environmental Impact of Energy Use: CO_2 Emissions in EU Countries 67
5.1.1 Data 67
5.1.2 Cross-sectional approach 67
5.1.3 Time series approach (Panel-Unit root-Test) 69
5.2 Tests for Environmental Kuznets Curve (EKC) 71
5.3 Natural Gas exports from Libya to Italy: Evaluation for the Natural gas Pipeline-New Developments 74
5.3.1 The Cost Benefit Analysis (CBA) 74
6 RESULTS 77
6.1 The CO_2 emissions in EU countries 777

6.1.1 Results of cross sectional approach 79

6.1.2 ARDL-ECM estimation.. 81

6.1.3 Results of Time series approach: Panel unit root test............................ 84

6.2 Results of EKC test- Italy... 86

6.3 Cost-Benefit Analysis Results.. 100

6.3.1 Sensitivity and Risk Analysis.. 104

7 CONCLUSIONS AND POLICY IMPLICATIONS 108

REFERENCES.. 115

APPENDICES 129

Appendix A: CBA Analysis of Green Stream-Natural-Gas Pipeline Project (Libya to Italy) 130

Appendix B: inverted (U-Shaped) EKC Test for Italy.. 133

LIST OF TABLES

Table 4.1: Proven Natural Gas Reserves (Billion Standard Cubic Meters) 49

Table 4.2: Main Gas Pipelines in Libya 58

Table 6.1: Summary statistics 78

Table 6.2: Stationarity test 79

Table 6.3: Cross-sectional tests for conditional convergence in the average annual rate of growth in per capita CO_2 emissions among European Union’s countries (N=21) 80

Table 6.4 : Table 6.4 : ARDL-ECM estimation results 81

Table 6.5 : Cointegration results 82

Table 6.6 : Diagnostic test.. 83

Table 6.7 : Panel Unit Root Test- Im, Pesaran and Shin (IPS) 84

Table 6.8 : Heteroskedasticity Test 85

Table 6.9 : Summary statistics 87

Table 6.10: Correlation test results 88

Table 6.11: Stationarity test results 93

Table 6.12: Cointegration test results... 93

Table 6.13: ARDL Cointegrating And Long Run Form -ECM estimation results... 94

Table 6.14: Granger causality results 97

Table 6.15: Diagnostic Test Results 99

Table 6.16: Greenstream-Pipeline Parameters Table.. 101

Table 6.17: Financial assessment to the Green Stream Pipelines (excluding) Bahr Esalam Phase ii 102

Table 6.18: Financial assessment to the Green Stream Pipelines (including) Bahr Esalam Phase ii 103

Table 6.19: Sensitivity analysis of NPV (@ 8,4%) of PV to Gas price (US$/mmbtu) 105

Table 6.20: Sensitivity analysis of NPV (@ 8,4%)of PV and to exchange rate (LD/US$) 106

Table 6.21: Sensitivity analysis of NPV (@ 8, 4%)of PV and to Inflation rate 107

LIST OF FIGUERS

Figure 1.1: Transporting Natural Gas from Libya to Europe ……..…………..…....5

Figure 1.2: Natural Gas Exports from Libya to Italy-Evaluation for the Pipeline New Developments ..……….……………..…...……….……………..…..….…………6

Figure 2.1: Environmental Kuznets Curve …..……………………………………13

Figure 3.1: Distribution of European Primary Energy Consumption…………..………24

Figure 3.2: Gas Demand Forecast in Europe over the 2010-2030……..…..……….25

Figure 3.3: Co2 emissions in EU countries………...…………………….………….28

Figure 3.4: The initial level of CO2 emissions and annual average growth rates over time…………….…………………………………….………….....……..………..29

Figure 3.5: CO2 emissions in Italy…………………..………..……..…………..….33

Figure 3.6: Proved Reserves of Natural Gas in Libya. ……...……………...………38

Figure 4.1: Libyan Total energy consumption……..………..………...………....44

Figure 4.2: Natural gas as electricity generator ……………..………..……………45

Figure 4.3: Top holders of proved natural gas reserves (tcm) in North Africa …….48

Figure 4.4: Libya’s Dry Natural Gas Production, Consumption and Exports (2000-2015)..50

Figure 4.5: Gross inland consumption-primary products of Italy and the EU countries.....…………………………………………………………………….53

Figure 4.6: Natural Gas Consumption in Italy: 2005 – 2016…….………..…….…54

Figure 4.7: Fossil fuels sources of electrical energy in Italy in 2015…………… …55

Figure 4.8: Bahr Essalam Field………….……………………….…..….………….64

Figure 6.1: L CO_2 emissions. ……………..……..………….…………...…………90

Figure 6.2: L Energy Consumption………..…….…………...………..……………90

Figure 6.3: L Globalization ……………..……………….……….…..…….…91

Figure 6.4: L Real GDP…………….……………...…….………………...….91

Figure 6.5: Sensitivity analysis (Gas price) …………….….………………..…106

Figure 6.6: Sensitivity analysis (Exchange rate) ……………..…….…….………….106

Figure 6.7: Sensitivity analysis (Inflation rate) …………….….…………..…….….107

Chapter 1

INTRODUCTION

In addition to being the holder of Africa's largest proved crude oil reserves, Libya is a significant holder of natural gas reserves as well having the third largest proved reserves in North Africa. This gives Libya a possibility to play an important role in European natural gas market. We believe that Libya has a significant potential to be a strategic supplier as compared to other natural gas suppliers to Europe in the region. For instance, in Algeria, it is expected that the availability of natural gas for exporting will be restricted (Aissaoui A. 2016) and (Michelon A. et al 2017). Furthermore, exporting natural gas from Algeria to Italy via Tunisia as country transporter makes Algeria to be less attractive in terms of costs of transaction compared with importing directly from Libya.

As gas became a desirable substitute to oil for environmental concerns, the attention made to countries export natural gas. Libya, given its reserves and annual production, is considered among countries with high potential to increase supply of natural gas, and appears to have significant probability to increase production in the medium to long term. In addition since pipelines remain the dominant for the methods of transportation of natural gas, Libya seems to have advantages with high probabilities to export more gas by pipeline which has saver option, comparing with other producers in the region.

So one of the main objects of our research is to highlight the potential of Libya in the natural gas market in the region, which we believe is very important for decision makers in the energy sector in Libya. In spite of the huge reserves of natural gas in Libya, natural gas did not get enough attention that should be given to, by policy makers when it comes to natural gas industry where the main focus is on oil sector.

One of our main motivations to predict a significant role for Libya as net natural gas exporter is its proved reserves. Libyan proved reserves of natural gas are about 55 trillion cubic feet (tcf), although the period between 2004 and 2015 witnessed a dramatic increase in production of natural gas, the reserves remain stable during last decade. With reserves to production ratio above 100 years, Libya has the ability to produce gas not less than 100 years with output level of 10 bcm with potential to double this production (Mac Donald M.(2010) & Hanfer and Tagliapietra (2013)). And once the situation in Libya recovers and stabilizes from the recent political uprising and the national economy recovers, the level of gas exports could undoubtedly increase.

It became a priority for European countries to achieve diversification in Europe’s gas supply especially to reduce dependence on Russian gas. Consequently, in this regard it is expected to rely on other options in the Mediterranean region and demand more natural gas from other natural gas exporting countries close to Europe such as Algeria and Libya. From supply side Libya is on the top of the list of proved natural gas reserve holders, and is expected to be a hot spot for exporting gas to Europe where this likelihood increases with the recent natural gas discoveries made by the giant Italian energy company Eni. However, in spite of the huge reserves of natural gas in Libya, natural gas did not get enough attention that should be given to, by policy makers when it comes to natural gas industry where the main focus is on oil sector.

In Europe the natural gas market there is an upward trend on demand side. It is believed that natural gas is indeed a sustainable option in the long-term. Therefore, to cover the gap of natural gas demand beyond 2015, Europe needs to seek further resources to import natural gas from alternative sources (Bonhomme, 2013). If the trend of the reduction in Europe’s domestic gas production from existing fields keep continues as it is, in addition of reducing its imports of high cost LNG that would unquestionably persuade the needs for Europe to improve its energy structure by constructing new pipelines to reach alternative natural gas sources. It can be argued that there is emerged need for Europe to get other alternative source of natural gas such as Libya.

Italy has a relative importance in this study. Italy is seen as a trading hub for importing natural gas from Libya and then forwarding to the rest of Europe. Italy is the main trade partners to Libya. In addition of being the top destination for Libyan oil exports, Italy is at the top of the list for natural gas exports as well.

In Europe in order to obtain sustainability, less efficient power plants are shut down and the electricity sector shifts towards even more efficient energy sources such as natural gas and renewable energy. Natural gas is considered a competitor to oil as energy source, and has a pivotal role in electricity generation. Therefore Natural gas is becoming attractive fuel compared with other alternatives as gasoline and diesel. Natural gas and renewable energy have a significant and vital role to play in the global transition towards a sustainable low-carbon economy, in both power generation and industry (IEA 2016).

Thus examining the convergence would open the opportunity to exporting natural gas as a better alternative to gasoline and coal in terms of CO_2 emissions. According to center for climate and energy solution, it is believed that expanding use of natural gas, as a replacement for coal and petroleum, is already reducing emissions of carbon (Center for Climate & Energy Solutions, C2ES, 2013)[1]. In this sense that might be a significant motivation for natural gas suppliers. For these countries if there is evidence of convergence in European Union (EU) countries that means they tend to move towards lower CO_2 emissions energy sources, this refers to potential demand for other fossil fuels. For instance, Libya currently exports more than 30 per cent of Italian needs of natural gas; therefore for Libyan energy[2] sector and so for policy makers such study could shed light for the potential for more exports of natural gas to Europe generally and to EU specifically.

It is stated that EU countries are net importer of natural gas, and progressively relying on limited suppliers (K. Talus, 2011). Consequently, in this regard it is predicted to rely on other options in the Mediterranean region and demand more natural gas from other countries close to Europe such as Algeria and Libya. As a country, closely, located to net importer, Libya should be considered as important promising supplier in a strategic position to Europe. Hanfer and Tagliapietra (2013) predicted significant increase in the exports by 2030. Therefore, Libya has the potential to be an importnant net exporter for natural gas. This can be accomplished

[1] C2ES: https://www.c2es.org/
[2] Libya has massive proved reserves of natural gas which can meet European needs especially in the peak season during winter.

if libya expands the natural gas production volumes by the developed existent pipelines Green Stream pipeline and export natural gas to Europe via Italy.

Figure 1.1: Transporting Natural Gas from Libya to Europe
Source: ENI, https://www.eia.gov/todayinenergy/detail.php?id=3570

The main objectives in this thesis are:

1. Testing CO_2 emissions convergence in EU countries. To see whether EU countries are diverging away from pollution and moving towards more environment friendly sources of energy such as natural gas.

2. To evaluate the environmental degradation in Italy, Environmental Kuznets Curve (EKC) hypothesis is tested. This is because Italy is the closest destination for Libyan natural gas exports, so we need to check whether Italy is moving away from high emission energy source use.

3. Can Italy be an energy hub to Europe by importing gas from Libya?

4. Examining the Libyan's potential to play a central role in meeting European demand for natural gas. Therefore we evaluate the proposal to increase

natural gas exports by developing the existing natural gas pipelines and examined using financial evaluation by cost and benefits analysis (CBA) for the most recent developments in Bahr Essalam in Green Stream pipeline (Figure 1.1 & 1.2).

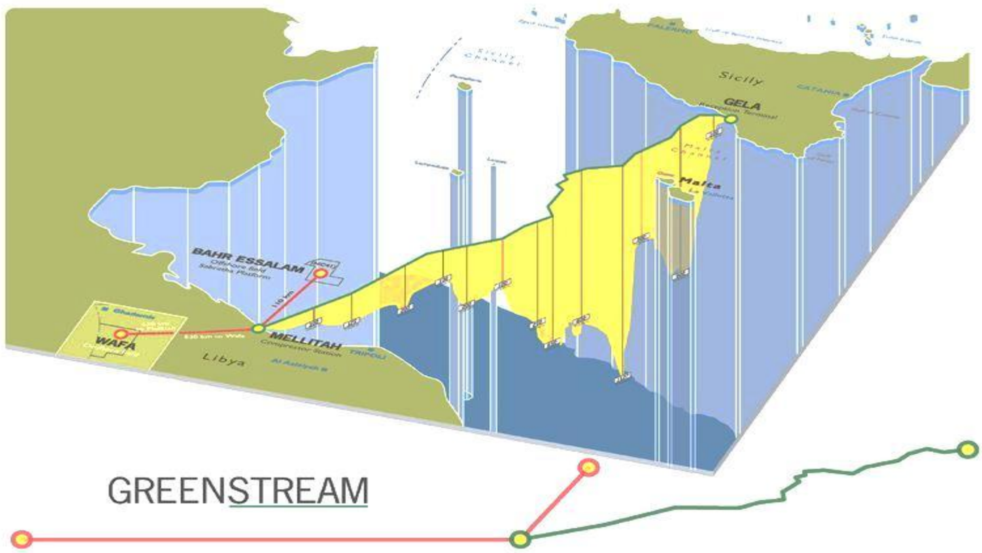

Figure 1.2: Natural Gas Exports from Libya to Italy: Greenstream Pipeline.
Source: www.greenstreambv.com/en/

The structure of the thesis is as follows. The thesis consists of six chapters. First chapter, which is also the current chapter, is the introduction. In this chapter the motivation and the purpose of this study are emphasized. Then chapter two briefly review the literature regarding CO_2 emissions convergence, EKC and financial assessment for pipeline projects. Chapter three provide a review of the developments in natural gas demand in Europe, in addition to the environmental issues, with more focus on Italy for the special position as main trade partner to Libya. Chapter four is about energy sector in Libya with focus on natural gas industry. Chapter five studies the methodology adopted in this research. This chapter is divided into three sections: section one is about testing the convergence in CO_2 emissions in EU countries to inspect the tendency in EU countries for cleaner energy source. Section two refers to testing the Environmental Kuznets Curve (EKC) relationships in the Italian economy specifically due to the fact that Italy is the number one destination for Libyan natural gas exports. Finally section three includes an evaluation and financial assessment to Green Stream Pipeline for exporting natural gas to Europe in Libya with findings. Final chapter is the conclusion and policy recommendations.

Chapter 2

LITETEAURE REVIEW

This chapter has three parts to breifly review the liteteature regarding the three methodology which are used in this study. First part regarding the covergence in CO_2 emissions in European Union (EU); second; EKC in Italy and finally the CBA analysis for natural gas pipeline in Libya.

2.1 Convergence of CO_2 emissions

The term convergence refers to the idea that per capita CO_2 emissions will converge toward lower emissions per capita in the long run. For the convergnce of CO_2 emissions emissions the existing literature shows that researchers have used different methods to test convergence in CO_2 emissions. Convergnence tests started with testing income convergence in USA by Loewy and Papell (1996) and their results show that regional incomes are stochasticlly converging and Carlino and Mills (1996) in their reply to Loewy and Papell study they used ADF-unit root test to investigate convergence and found that stochastic convergence is a necessary but not sufficient condition for per capita income convergence in the US regions.

In some researches cross sectional data are used to test sigma convergence (σ-convergence) and conditional convergence (β-convergence)[3], such as testing the convergence in CO_2 emissions where countries start with high level of emissions tend to decline over time with lower emission growth than countries starting with

[3] That, the dispersion in the cross-sectional variable is declining over time. In other words whether, CO_2 emissions are converging over time or not.

low emissions (Jobert et al 2010). However, as stated by Avila (2008), time series approach (stochastic convergence) gives more siginficant results than cross sectional approach since the former might result in spurious convergence[4].

Most of the studies support the idea that cross-sectional approach uses the average only and assumes homogeneity among all estimated parameters. Therefore, it is suggested by many studies such as Strazicich and List (2003)[5] , Avila (2008) and Jobert et al (2010) to employ a panel-based unit root test to examine convergence in per capita CO_2 emissions, even under the existence of heterogeneity in per capita CO_2 emissions. In their study they employed Bayesian shrinkage method to test convergence in CO_2 emissions in the EU 27 countries during the period of 1971-2006 their finding support the absoulte convergence and stable conditional convergence with relative importance to industry share in GDP in reducing CO2 emissions . In their model Strazicich and List (2003) tested the absolute and the conditional convergence of CO_2 emissions for 21 OECD countries during 1960 to 1997. They also, used unit root test for panel data stationarity finiding a strong evidence among CO_2 emissions. Their results support the existence of absolute convergence in the emissions and conditional convergence.

Another methodology to test convergence is to use time series approach to test behavior of per capita CO_2 emissions, in other words to check the stationarity using panel data as in the approach used by Im K. S., M. H. Pesaran and Y. Shin (2003)[6] and Christidou M. et al (2013). The approach that using panel based unit root test for

[4] This means cross section analysis may lead to rejections of hypothesis of divergence.
[5] One of the main studies in this area and their model is adopted in this study as mentioned later.
[6] Initially IPS approach tests the unit roots among heterogeneous panels introducing a standardized T-bar test statistic.

convergence in CO_2 emissions indicates that if CO_2 emissions were stationary, it implies that any shock to CO_2 emissions would be temporary and so CO_2 emissions will converge toward the average over time. In fact these studies that used time series and panel data approach were attempts to resolving problem of heterogeneity. Since cross sectional approach neglects the potential of heterogeneity and assume that homoscedasticity in the CO_2 emissions variable, while using time series or panel-unit- root test allows testing convergence even with possibility of existent heterogeneity among data. So, following the pioneering work of Im K. S., M. H. Pesaran and Y. Shin (2003) many studies have been carried out to analyze existence of convergence by using a unit root test for dynamic heterogeneous panel data. For instance, in their study Gaulier et al (1999) have tested convergence in GDP of three grouped panel data regarding Europe, OECD countries and overall around the World over 1960-1990 by using panel data-unit root-test approach.

In the line with the pioneering work of Strazicich and List (2003), Avila (2008) also tested convergence in carbon dioxide emissions among 23 OECD industrialized countries over the period 1960-2002 Also, Christidou M. et al (2013) examined the stationarity of CO_2 emissions in 36 contries 1870-2006 finding the emissions were stationary. Aldy (2006) tested convergence of CO_2 emissions in the world and found evidence of convergence in 23 countries of (OECD) whereas emissions were diverging amonge 88 country during 1960-2000 using both cross-sectional data and unit root test. Also, Aldy observed that the sample size affects the results of testing the convergence that when they extend the sample under consideration, the emissions in these countries were diverging.

In other studies such as research conducted by Oliveira and Mores (2015), researchers used a panel data approach to test convergence in per capita carbon dioxide emissions for 118 countries including OECD countries their finding support the increase in the convergence rate if country specific effects are considered in the test and Asian and Latin American countries converge faster than other average countries. Also, Das (2013) used the same methodology to test convergence in CO_2 emissions among Indian states during 1980 to 2000. Furthermore, Sek (2010) tested stochastic convergence of CO_2 emissions in Malaysia using the same method concluding existence of convergence.

In addition to these two main approaches there are other studies which used different approaches to test convergence in per capita CO_2 emissions. In their study regarding testing convergence in per capita CO_2 emissions. For example Criado and Grether (2011) conducted a robust distributional approach using data of 166 countries over the period 1960-2002, using both absolute and relative levels of per capita CO_2 emissions. Their work resulted in supporting the view that type of convergence dynamics are subject to the method or the data used, such as whether CO_2 emissions were in absolute or relative levels. Their results show that when levels of per capita CO_2 emissions are used a significant evidence of divergence is observed. On the contrary the findings show convergence when they used relative measure of per capita CO_2 emissions.

Ezcurra (2007) examined the spatial distribution of per capita CO_2 emissions in 87 countries over the period of 1960-1999 using a non-parametric approach and found evidence of convergence and the importance of tempertature and income as significant determinants of changes in CO_2 emissions while trade openness was not significant. Moreno, Juan & Padilla, Emilio. (2011) employed the endogenous approach and exogenous approach to examin the degree of polarisation in the international distribution of CO_2 emissions per capita in EU countries. Their results show evidence of convergence in CO_2 emissions in the mid-1990s in EU countries as the contribution of energy intensity to between-group differences has declined. Jalil (2012) employed log-t-test, initially used by Phillips and Sul (2007), in his work Jalil tested the convergence in per capita CO_2 emissions for 126 developing countries over the period of 1971-2009, the results support the convergence while there was a divergence or the emissions when they tested in three regions.

In the first part of the empirical work in this study we followed the approach used by Strazicich and List (2003) in order to test convergence in CO_2 emissions in EU countries. This will be explained in details in chapter 5.

2.2 Environmental Kuznets Curve test (EKC)

The Environmental Kuznets Curve (EKC) relationships is orginated from the work by Kuznets (1955) regarding GDP growth and pollution. It implies that the environmental quality will be worsen at early stages of economic growth, in other words the more economic development the more damage occurs to the environment untill turning point where the CO_2 at maximum level then start declining as economic growth increase at a later stage as shown in Figure 2.1.

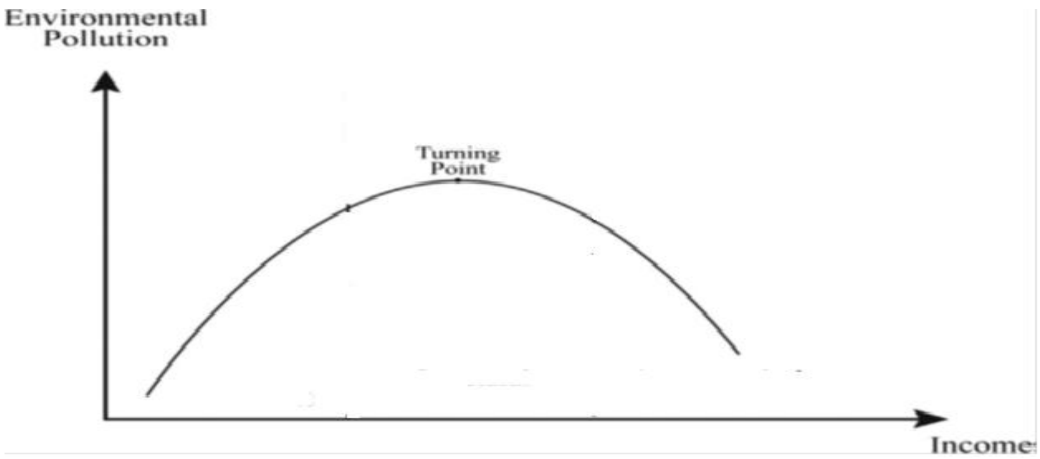

Figure 2.1: Environmental Kuznets Curve

EKC implies that the environmental pollution is expected to have a positive relationship with the level of income (economic growth) before the EKC turning point which refers to emissions at maximum level and then a negative relationship beyond it. That is EKC relationships suggests an inverted U-shaped relationship exists between income (economic growth) and CO_2 emissions.

EKC model is widely used in the literature since then. Theoretical and econometric contribution of the EKC are made by researchers such as Stern (2004). Acording to the theoretical background of the EKC, at early stages of development, the economic growth leads to environmental damage, but after a certain point the increase in economic growth causes a reduction in CO_2 emissions (Acaravci and Ozturk (2010); G. Bölük and M. Mert (2015); Bilgili F., E. Koçak and Ü. Bulut (2016) and Stern (2004)).

However, the EKC analysis is sensitive to various factors like time zone, modeling technique and kind of pollution proxies used in the model Lacheheb M. et al (2015) and Özokcua S. and Ö. Özdemir (2017) and the EKC analysis also may show slightly different results when it is applied in developing countries which are adopting developed environmental standards (Stern, 2004). There are other studies which included some other important variables like energy consumption and globalization in addition to the GDP variable, such as work done by Shahbaz et al (2010, 2013) for some other single European countries.

We conduct a test for the EKC in our study to test the envirommental damage in Italy and check what factors degrade the environment most significantly. In our study also it is important to include other significant variables to explain behavior of CO_2 emissions in Italy. These variables are globalization and energy consumption. This is because of importance of their impact on environmental quality. The relationship between greenhouse gas (GHG) emissions, globalization, energy consumption and economic growth, has been an important topic globally. According to EKC the environmental consequences of economic growth, globalization and energy consumption are degrading environmental conditions by increasing CO_2 emissions in the short run, while the same variables improve environmental quality by lowering CO_2 emissions in the long run. Shahbaz et al (2017) found that globalization, economic growth and energy consumption significantly increase carbon emissions in the short run.

Shahbaz et al (2013) states that globalization encourages technical innovation, and boosts environmental standards. Globalization improves the environmental conditions by enhancing the productivity of total production factors throughout increased trade activity and risen economic activity via foreign direct investment and transactions of advanced technology. They also state that globalization enables governments to change trade policies by reducing trade barriers to the import of energy-efficient technologies in Shahbaz et al (2017).

On the other hand Snyder (2008) shows that globalization harms the environment and accelerates the transfer of pollution from developed countries to developing ones where environmental regulations are lacking. The relationship between CO_2 emissions, globalization and energy consumption has been analyzed by many researchers. Several empirical studies such as Lucas et al. (1992), Leitão and Shahbaz, (2013); Shahbaz et al. (2013) and Leitão (2014) tested the relationship between globalization and environmental change. Shahbaz et al (2015) studied the impact of globalization in China and concluded that globalization is reducing CO_2 emissions. Also, it is concluded by Leitão (2014) that globalization is a significant factor to encourage the environmental commitment.

Although energy consumption is an important factor in the growth process, it has negative impact on environment. The question of causal relationship between energy consumption, environment and economic growth has been studied in the economic literature. The relationship among these variables is interesting that energy consumption is determined by economic growth, and more economic growth leads to increase in energy consumption and hence increase CO_2 emissions. For instance Kais Saidi and Sami Hammami (2015) show that economic growth leads to more energy consumption and CO_2 emissions, and the energy consumption directly or indirectly increases economic growth. In his study Nuno Carlos Leitão (2014) pointed out that although energy efficiency is crucial to explain the economic growth, energy consumption has not been used commonly to explain economic growth yet. Leitao concluded that the energy consumption presents a negative impact on economic growth in the long run. However, Shahbaz et al (2015) show that any attempt to reduce energy consumption will result in declining economic growth in China.

Globalization can be seen as an opportunity for economic growth. In addition Shahbaz et al (2015) stated that globalization improves the environmental quality. Therefore when a country reaches higher living standards through globalization process, people's awareness increase and they demand improved environmental quality. Gohar et al (2016) explain that the higher the economic growth is the higher the environmental standards and adoption of energy-efficient technologies. Therefore, as countries become more energy efficient, the more they become technologically designated within environmental standards and more able and motivated to reduce emissions by related legislation. Therefore, globalization is considered as one main determinant for changes in the economic growth (Leitão, 2014).

Italian globalization process, with no exceptions, also raises the environmental concerns. But globalization, in the long run, may also contribute to reducing environmental degradation; that is due to globalization the increase in income and usage of efficient technology in Italy and hence meeting environmental standard. This process of globalization in Italy could be tested through the hypothetical environmental Kuznets curve. These variables will be included in our analysis in explaining the changes in the CO_2 emissions.

Related to EKC analysis referring to Italy there are very limited empirical work regarding CO_2 emissions in Italy. Convergence tests of CO_2 emissions for Italy have been usually done within panel data among European countries and a single country test is not very common. It is stated that a single country investigation is recommended for a specific historical experience regarding environment effects of economic growth in a country rather than cross sectional analysis (Annicchiarico, Bennato & Chini 2014). In their study they examined the relationship between economic growth and CO_2 emissions in Italy for 150 years' time period. Because of the excessive research for grouped-countries it is believed that there is deficiency in policy implications for individual countries, because it is hard to distinguish which policy is the best for which country. For instance, there is need for testing EKC for individual countries to figure out the most suitable policy regarding air pollution (Lacheheb, Abdul Rahim, & Sirag, 2015) and also, for the relationship between carbon emissions and economic growth (Ozturk & Acaravci, 2010) and (Sek, 2010).

EKC gained popularity in the more recent studies due to the fact that there is no obligation to policy prevention since the effect of economic growth on CO_2 tends to become negative at the turning point, the application of EKC is largely becoming more important (Lacheheb et al., 2015).

2.3 Economics of Libyan Natural Gas

The third important subject in our research is to study the economics of the natural gas exports from Libya to euorpe. In the literature it is recognized that natural gas, environmentally, has a significant position among other fossil fuels and continues to increase its share as a source of energy over the world. Mason & Wilmot (2014) state that natural gas is expected to develop a significant role in energy resources markets, and its share in European energy consumption is anticipated to keep increasing ((Stern, 2015) and Ozge et al., 2013)). Moreover, technically, the usage of natural gas is flexible and easy to switch from coal to gas or vice-versa in mix form to absorb fluctuation in relative prices (Macmillan et al., 2013). Natural gas transportation cost for industry and power generation is 0.50 EUR/GJ[7] while other

[7] (GJ) is natural gas prices Euro per Giga Joule.

energy sources 10 EUR/ton for Coal and 60 EUR/ton for liquid fuels, so it can substitute other fossil fuels (Francesco Angelini, 2011). The demand of natural gas in Europe is expected to increase ((Seele 2011), (WINGAS, 2016), (Ozege, 2013) & (Francesco Angelini, 2011)). Other studies recommended building new natural gas pipelines to south European countries in the works of (Hafner & Tagliapietra, 2013) and Mac Donald (2010)). In their study Hafner & Tagliapietra (2013) regarding the transnational, onshore gas pipeline connecting Mellitah to Gabes (Tunusia) which has been proposed with a distance of 266 km long with an initial capacity of 2 bilion cubic meter (bcm) per year, they pointed out that there is still no certainty about this project, and the future of the project is dependent on the Libyan government guaranteeing the gas supplies.

From demand for natural gas, there have been several studies discussed the shortage in natural gas market in Europe[8], such as the study by Anouk Honoré (2014), Stern (2015), and Mac Donald (2010), they discussed the growing European demand for natural gas and discuss how important to achieve diversity in natural gas supplies, referring to build new routes to achieve these goals. Not surprising that one of the best alternatives could be southern Mediterranean Sea and that is what we try to examine here in Libya as one of these options using Cost and Benefit Analysis (CBA).

The methodology of CBA conducted in this study has been used in several empirical studies regarding evaluating natural gas pipelines or LNG construction projects in different parts the world. For instance the scenario analysis for Cyprus Aphrodite

[8] Due to the fall in domestic production in European Union countries, they dramatically depend on imports to meet their growing natural gas requirements, especially after the Russian conflict with the EU.

Gas was done by MIT[9] experts (Paltsev et al., 2013) and other studies such as Angelini F. (2011) Jenkins et al (2019), Jenkins (1999), Salci, Sener and Jenkins (2016), Jenkins et al (2007). Also, CBA is used to assess other projects such as the study regarding the providing access to potable water in Nigeria (Jenkins G. et al 2018), and the study about vulnerable households in Burkina Faso and Niger (Jenkins G. et al 2018). And the same analysis is adopted for a case study about sustainable poverty reduction in Zimbabwe (Jenkins G. et al 2018). Another example the study carried out by Michelon A. et al (2017) used the same assessment method for a proposed pipeline project in the Eastern Pyrenees-the South Transit Eastern Pyrenees (STEP). In his study he analyzed several scenarios to explore the potential for STEP to provide economic benefits. Also, an empirical study was used for evaluating the power utilities in sub-Saharan Africa (SSA) to compare the economics of fuel savings and GHG savings made from investing in solar photovoltaic power generation plants to diesel power plants (Baurzhan, S., & Jenkins, G. P. 2016). Also, the same CBA analysis is required by EC (European Commission) in evaluating the very large projects, such investments with a total cost of more than 50 million euro, or 25 million euro for environmental projects before taking any decision, (European Commission,2006) cited in (Michela & Massimo 2009). In addition, the same methodology is used for evaluation of other projects rather than natural gas. Such as, the study was done by Zayas et al (2016) regarding water project to specify the suitable tool for evaluating water reuse schemes. CBA is also used for different objective such as from war respective view of the 2003-2011 Iraq War, to estimate the gained and lost value of human lives, economic value and influence value, and

[9] Massachusetts Institute of Technology (MIT)

show how different weights impact the decision of whether to start war in a different way (Hausken, 2015).

In Libya CBA for natural gas studies are somewhat missing in the literature. For simplicity and flexibility we adopt similar analysis that was carried out by Mac Donald (2010)[10], which was related to Arab Gas Pipeline networks by employing the same approach. It allows us revisiting the previous studies and evaluate our argument of whether expanding production of natural gas and transport from Libya to Europe financially is attractive or not. The study examines this and evaluate the benefits and costs of the expanding exports of natural gas from Libya to Europe via Italy by the developed Green Stream pipeline to export natural gas.

[10] Also, due to the civilian conflict and limitation for direct data sources; we adopt secondary sources i.e. the same calculation for WACC used in this study see the appendix.

Chapter 3

NATURAL GAS DEMAND IN EUROPEAN UNION

In order to obtain sustainability, less efficient power plants are shut down and the electricity sector shifts towards even more efficient energy sources such as natural gas and renewable energy. Natural gas is considered a competitor to oil as energy source, and has a pivotal role in electricity generation. Therefore Natural gas is becoming attractive fuel compared with other alternatives as gasoline and diesel. Natural gas and renewable energy have a significant and vital role to play in the global transition towards a sustainable low-carbon economy, in both power generation and industry (IEA 2016).

Natural gas continues to increase its' share as source of energy over the world, due to natural gas reliability technically and financially especially for electricity generation purpose. Technically the usage of natural gas is flexible, that during demand peaks period natural gas has a significant advantage which can be used with other renewable options like wind power and easy to switch from coal to gas or vice-versa in mix form to absorb fluctuation in relative prices (Macmillan S. et al 2013). And it is stated that it has high probability to develop a significant role in energy resources markets in the future (Mason & Wilmot, 2014), more specifically the share of natural gas in European energy consumption is expected to keep increasing in future (J. Stern, 2015) and (Ozge et al., 2013). In addition, in terms of transportation costs to industry and power generation are lower when natural gas is used just 0.50 EUR/GJ than other energy sources 10 EUR/ton for Coal and 60 EUR/ton for liquid fuels, so, along with the observed trend in Europe natural gas can potentially replace the use of other fossil fuels (Angelini, 2011).

Acknowledging this trend, demand of natural gas in Europe, is expected to increase. It is stated that Europe is predicted to keep the increase in the share of natural gas in total primary energy consumption (Angelini, 2011). According to international energy reports the consumption of natural gas among 27 members of European Union in 2012 reached 490 billion cubic meters per annum and predicted to increase to more than 550 billion cubic meters (bcm) by 2020 ((Seele, 2011) & (WINGAS, 2016)), and predicted by another empirical study to be between 572 and 646 bcm in 2020 (Ozege, 2013).

On the other hand, in Europe there is shortage of natural gas because of the gap between supply and demand of natural gas, this is due to the fall in domestic production, so European Union countries are dramatically depend on imports to meet their growing natural gas requirements. This brings up a pressure on finding other sources to fulfil these needs mainly due to Russian conflict with the European Union. Therefore, many studies such as Anouk Honoré (2014), Stern (2015), and Mac Donald (2010) discussed the growing European demand for natural gas and raise the importance of achieving diversity in natural gas supplies and emphasize the need to reduce the European dependency on a single supplier of natural gas. This implies identifying and building new routes to achieve these goals. Not surprising that the best alternatives to Europe in order to do so, might be to obtain their need from southern Mediterranean Sea.

In the following sections we provide a brief review of the developments in natural gas demand and supply in Europe, then a discussion for challenges that may face Europe to secure reliable source to meet its needs within the region in the natural gas market, in addition to the environmental issues, with more focus on Italy for the special position as main trade partner to Libya.

3.1 General overview on natural gas market

The natural gas is seen as an appropriate choice for many countries keen on adoption for cleaner and cheaper fuels. It is stated that natural gas is inexpensive and a good complement to renewable sources (Bonhomme, 2013). Both liquefied and piped natural gas is essential for any nation to achieve its targeted economic development. Natural gas represents significant percentage of imports of many countries over the world. However, Europe may have made the choice of a low-carbon economy, due to the desire of some European countries to lower costs, and the increase call for using coal, as alternative of petroleum products, European demand on natural gas has been declined. Nevertheless, this decline in European demand on natural gas due to several reasons and the rising in oil prices, thus looking for cheaper fuels, yet, natural gas is still needed. It is expected that the share of natural gas in the global energy mix will continue to rise, with growth of (2.4 %) annually until 2018 (IEA, 2014), and investment in gas market is expected to maintain positive growth rates over the world (World Energy Outlook, 2014).

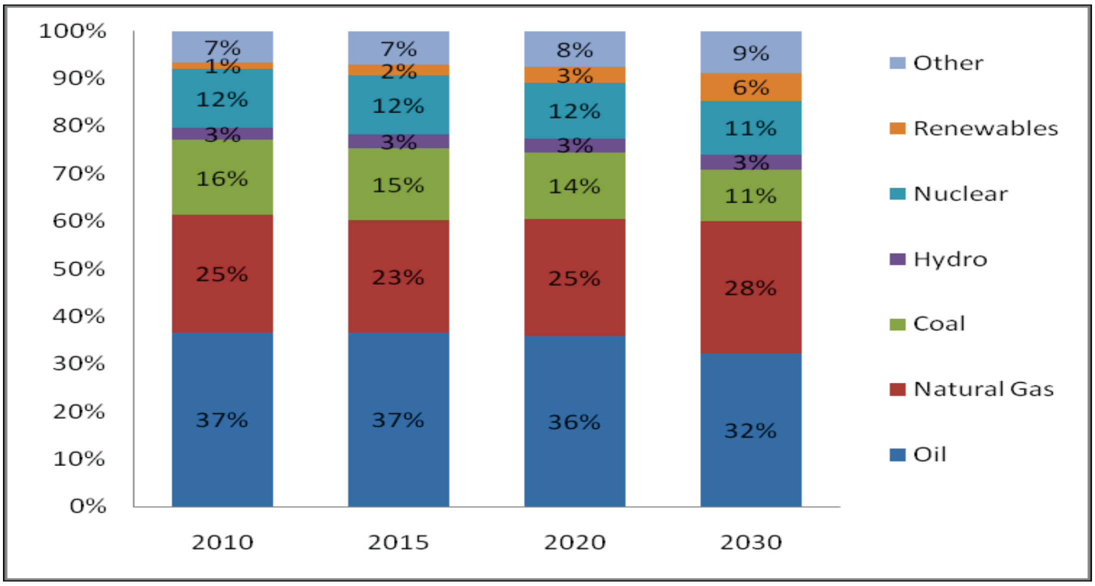

Figure 3.1: Distribution of European Primary Energy Consumption. Source: CERA Global Redesign (2012). Adapted from Bonhomme, (2013).

According to Bonhomme (2013), even if natural gas demand has declined in Europe, this situation is not expected to continue in the long-term. In his argument Bonhomme, stated that renewable energy, such as wind and solar power generation, is not yet strong enough, and need long way to be dependent on without extra financial support, moreover, using natural gas could reduce CO_2 emissions by 740 million tons by 2035 (see Figure 3.1 & 3.2). In many countries demand for natural gas have increased and expected to keep that trend in future, as it is in Japan[11] and expected to rise in the near future, especially in the advanced industrialized economies such as Germany and France in the EU and predicted that natural gas to be the fastest consumed rate among fossil fuels for at least next 2 decades (Gürel et al 2013).

[11] In Japan, three nuclear reactors at the power plant in Fukushima in March 2011 have melt down because of 9.2 richer scale earthquake and 17 meters high tsunami. This made a huge increase in Japanese natural gas demand.

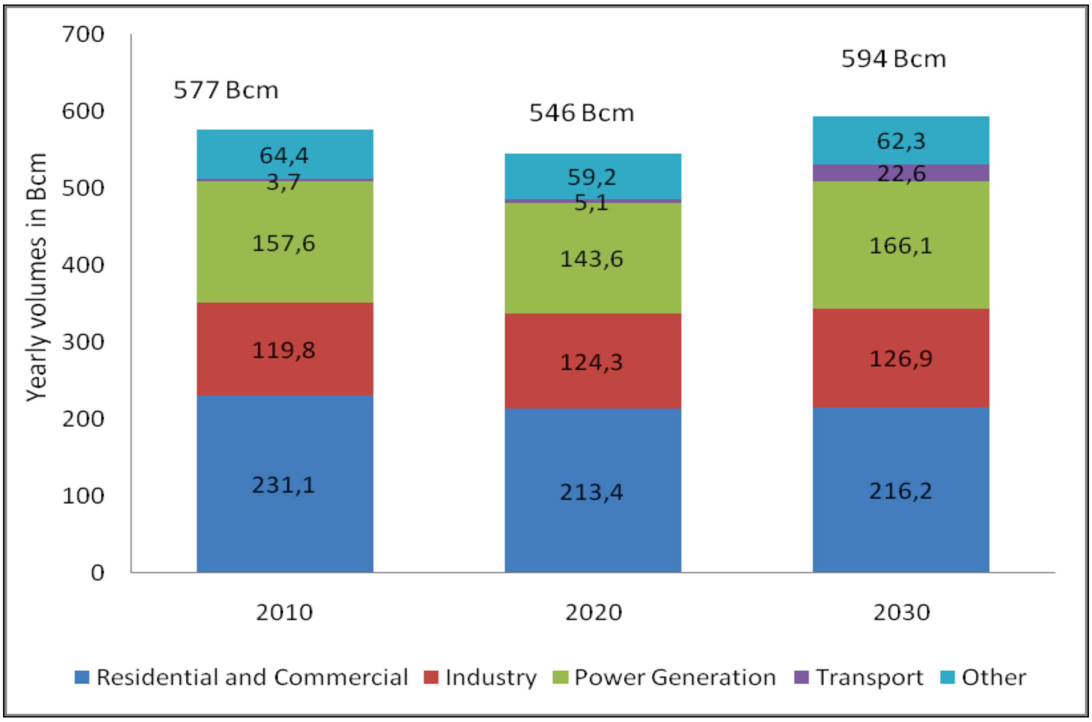

Figure 3. 2: Gas Demand Forecast in Europe over the 2010-2030. Source: CERA Global Redesign Oct 2012) Adopted from Bonhomme, (2013).

Moreover, the political conflict between Ukraine and Russia might highlight the critical need for European Union to search another source of natural gas other than Russia. The Russian natural gas provided to fulfill European Union's consumption need is about 30 per cent, via pipelines through Ukraine. Russian-Ukraine uprising and growing political conflict between Europe and Russia, may, as a result, push for a real crisis threatening to cut off supplies of Russian gas. The crisis between Russia and Ukraine emphasize the proposal in this study to seel other supplier such as Libya. The new road map of Europe by 2050 requires diversification of natural gas supply to secure its long-run demand by 2050. Regarding this issue Europe has already made few regulations and passed some directives about the security of gas supply through diversifications of gas routes.

3.2 The Environmental concerns: CO_2 Emissions in EU Countries

Another motivation for natural gas to be an interesting topic for us is the environmental warnings and the call for a cleaner energy usage. Due to increasing awareness of environmental concerns, emission convergence became a core focus for researchers and policymakers. Therefore, efforts have being paid towards reducing GHG emissions, thus more focus on the carbon di oxide (CO_2) emissions as one of the most alarming components of GHG. Testing CO_2 convergence is very important, especially for the industrial countries that are seeking long term goal of reducing CO_2 emissions by several plans, as using less gasoline and moving towards other fuel with lower emissions such as natural gas. Also, in terms of sustainability, it is stated that natural gas can contribute to reducing GHG emissions and can minimize transportation environmental impact and so enhance sustainability over the world (International Gas Union, 2012). Thus, it is important to accomplish convergence to guarantee allocation of CO_2 emissions (Romero and Avila, 2008). Therefore the convergence test determines whether or not these countries are taking serious measures towards achieving the long term goal of reducing CO_2 emissions or whether their measures succeeded.

3.2.1 CO_2 Emissions convergence: Literature review[12]

Throughout the literature it has been established by many researchers that corresponding to the growth of industrial activities which are unavoidable components of (GHG) are mainly CO_2 emissions. While the existing literature shows that there is a direct relationship between economic growth and CO_2 emissions, these developed economies try to reduce CO_2 emissions and gain less pollution rates. In doing so, testing convergence in CO_2 emissions became very significant for whether

[12] More about this is in chapter 4.

controlling CO_2 emissions in countries under consideration are making any notable progress[13].

3.2.2 Trend of CO_2 Emissions over the Period of the Study: A Graphical Analysis

A graphical presentation is given below to see the way of movements in CO_2 emissions over time, and a scatter diagram for annual average growth in CO_2 emissions together with level of emission in each country.

Figure (3.3) presents the general trend of CO_2 emissions by EU countries over the past three decades from 1980 to 2014. It shows that EU countries tend to lower their CO_2 emissions during this period. Except of the case of Estonia that emissions tend to increase during the last couple years, for all other EU countries , the curves are falling over time, in other words, they start with higher levels and then get smoother with a downward sloping trend. This can only be an indication for the existence of convergence in CO_2 emissions. Therefore, it is necessary to use an econometric model to examine whether the emissions in these countries converge or diverge.

[13] Convergence means that per capita CO_2 emissions will converge toward lower emissions per capita in the long run. See Annex I for the extended literature review regarding convergence.

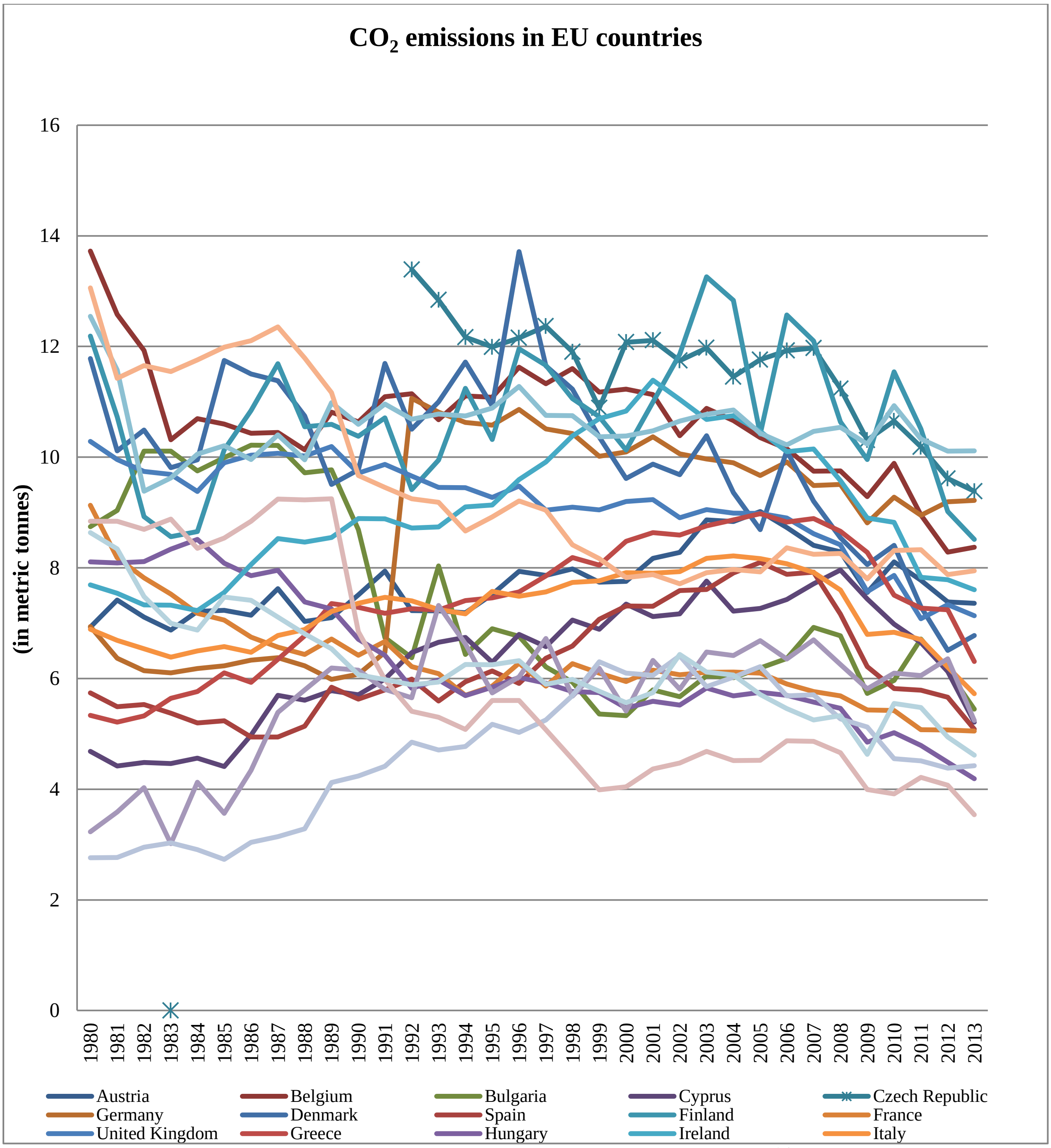

Figure 3.3 CO_2 emissions in EU countries (in metric tons)[14]

In addition a scatter diagram may help to understand the movements in the CO_2 emissions as shown in the graph given below. The scatter diagram plots the initial levels of emission and the average growth rates of emissions over the period of the study. From Figure 3.3 it can be seen that there is a negative relationship between the

[14] Data for the new members of EU are only available from 1990.

initial levels of CO_2 in 1980 and the average growth rates of CO_2 emissions. Also a linear regression is run over the scattered diagram. The negative slope of the linear regression implies a declining trend of emissions, meaning that countries with higher initial values of CO_2 emissions tend to have lower growth rates in their emissions over time. Thus, these findings increase the possibility of convergence among CO_2 emission in the EU countries.

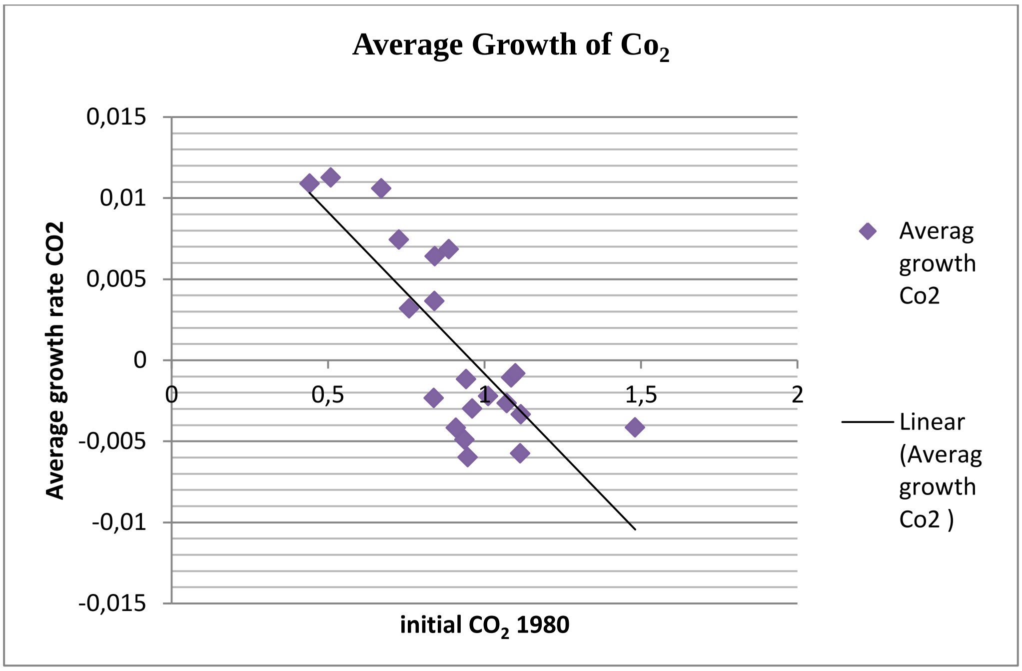

Figure 3.4 The initial level of CO_2 emissions and annual average growth rates over time

Reducing CO_2 emissions continues to be interesting topic up to the present time (Lin J. et al., 2018), also, (Acar S. et al., 2018) and (Shakouri & Yazdi 2018). And testing Convergence in CO_2 emissions can be seen as a significant indication for whether controlling CO_2 emissions in countries under consideration are making any notable progress.

Another interesting subject in our study is that examining the convergence would lead to discussion on exporting natural gas as a better alternative to gasoline and coal in terms of CO_2 emissions. According to center for climate and energy solution, it is believed that expanding use of natural gas, as a replacement for coal and petroleum, is already reducing emissions of carbon (C2ES, 2013). In this sense that might be a significant motivation for natural gas suppliers. For these countries if there is evidence of convergence in EU countries that means they tend to move towards lower CO_2 emissions energy sources, this refers to potential demand for other fossil fuels. For instance, Libya currently exports more than 30 per cent of Italian needs of natural gas; therefore for Libyan energy sector and so for policy makers such study could shed light for the potential for more exports of natural gas to Europe generally and to EU specifically. This was one essential interest of the initial motivation of this study and could lead to further studies regarding efficiency of natural gas for environment proposes and feasibility analysis regarding natural gas projects linking suppliers to EU.

Thus to explore the energy resources and environmental concerns in EU countries towards less emissions energy sources, a test for convergence in CO_2 emissions is done to evaluate trend in terms of efficient energy sources in chapter 5.

3.3 Natural gas demand in Italy

Europe, generally, is considered the main importer for Libyan oil and natural gas, and Italy is the top destination country for Libya. In our study, as mentioned earlier, we focus on Italy as well as the main importer of Libyan gas in Europe, and we give special consideration for Italy in our study. This is due to Italy’s location between one of the largest holders of proved reserves of natural gas, Libya, and largest natural gas importer in EU, Germany, so Italy can play a key role to supply gas to northern Europe by importing gas from suppliers in south Europe. This emphasizes the possibility of Italy to be as hub of natural gas by linking Libyan natural gas exports to European market.

Italy imports about 90 percent of its gas needs from Middle East and North African countries, and Italy is expected to increase its imports of gas especially from Algeria, Libya, and the Netherlands, to overcome any future crisis related with Ukrainian gas networks. The growing political conflict between Europe and Russia is one of our imprtant motivations for this study regarding the potential for Libya and geopolitical developments in natural gas trade in the region. That is Libya could be an attractive alternative option for Europe to obtain natural gas. Hence towards low emissions energy sources, natural gas seems to be an attractive option. Consequently, importing more natural gas could make Italy achieve environmental goals while meeting energy domestic needs, the next chapter is regarding the economics of importing natural gas by Europe from Libya.

3.4 Environmental policy in Italy

In order to reduce pollution, countries around the world take several steps regarding and climate changes. As a result of the obligations regarding reducing pollution, the environmental concerns in Italy are gaining a greater consideration. Therefore, Italy is expected to choose more environment friendly energy source.

The environmental issues globally, are continuously gaining a great consideration. Italy is no exception; as a result of the commitment regarding reducing pollution the country takes steps towards less emissions, including signing the European convention; the EU emissions trading system EU-ETS and the related protocols since 1979 (ISPRA 2014). A large part of global climate change and the greenhouse effect is due to emissions from carbon dioxide (CO_2) and other greenhouse gases (Lee & Chang 2009) and the CO_2 is considered as the source of 90 per cent of all the greenhouse gases (GHGs) emitted in the transportation field (Noceraa S. & F. Cavallaro 2011). Therefore CO_2 has received considerable attention regarding reduction of polluting gases. This study investigates the convergence in CO_2 emissions and estimates the environmental Kuznets curve (EKC) based on CO_2 emissions per capita, to evaluate the Italian consumption trend in terms of efficient energy sources, as indication for Italy commitment towards reducing CO_2 emissions.

Reviewing the developments in the environmental policy and CO_2emissions in Italy during the period of the study, it can be said that Italy has made some progress towards reducing pollutions emissions, despite the fact that there are other factors shaped the emissions trend beside the policy for less environmental degradation; the oil prices shocks in mid 1970s and 2005, second the economic crisis from 2008 to 2013. Thus, the main reason for the decline in emissions during mid1970's was due to the oil prices and in the 2008 attributed to financial crisis. As for the de-carbonation policy in Italy, generally it involves two main paths; the increase in gas usage share until reached the highest share in 2010, also using renewable plants for power generation, but gas still dominates the fuel mix though (Virdis, M.R. et al. (2015).

Following the trend in industrial economies, CO_2 emissions in Italy had risen in the late of 1940's reaching 76 per cent until sharply fall to 46 per cent in 1974, mainly due to replacing oil with natural gas (Boden, Marland, & Andres, 2011). It is reported that the energy sector is the main source of emissions, then comes transport sector and the reduction in emissions during the period from 1990 to 2012 was about 87 per cent in Italy and generally credited to the transport sector, and specifically, the cut in emissions was from road transport and other mobile sources and machinery ((ISPRA 2014) & (Virdis, 2015)). An example for these efforts towards more efficient energy use in the transportation sector, that77 per cent of natural gas-powered vehicles in the European Union were in Italy (IEA. 2016).

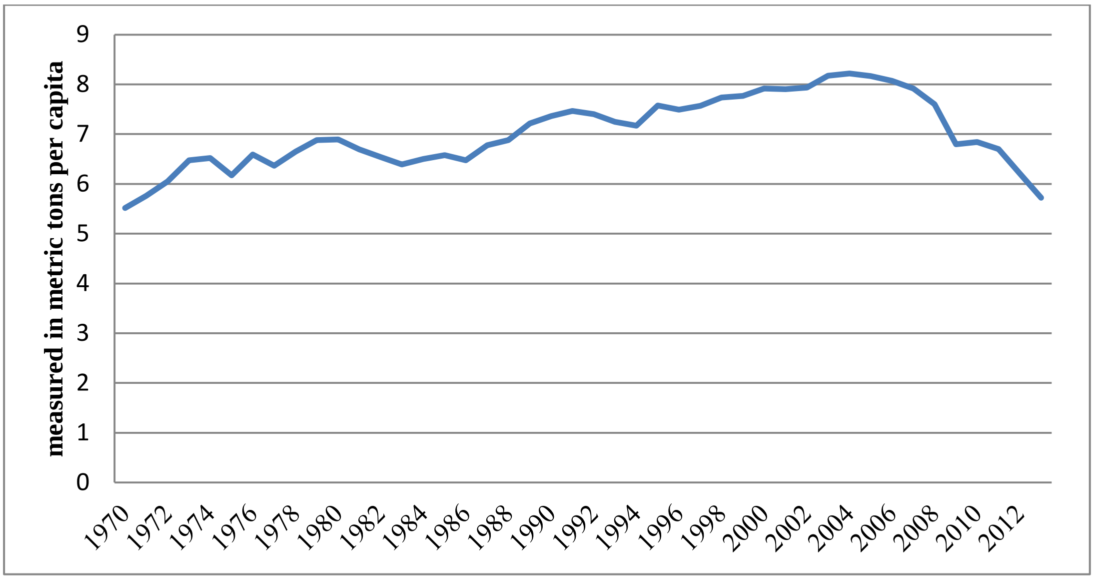

Figure 3.5: CO_2 emissions in Italy

As presented in Figure (3.5) CO_2 emissions initially increased during 1970 to 1974 then started to decrease and continue to slightly fluctuate, until progressively decreased from year of 2008**,** until dropped to 572381 meteric tons in 2012 compared with before. According to the US Department of Energy in the early years up to 1974 the per capita CO_2 emissions in Italy grew rapidly, and emissions increased by a factor of 7.5. The reduction in the per capita CO_2 emissions in Italy mostly can be attributed to two reasons; due to the change in the energy policy in Italy towards more consumption of natural gas instead of oil as a result of oil price shock, and so the increase share of natural gas in the fossil fuel basket, this can be reflected in the contracts made for importing more natural gas for example from Algeria and second reason is due to energy policy it is due to the financial global crisis in 2008.

However, the reduction in CO_2 emissions could be resulting from the energy strategy adopted by Italian plocy makers regarding reducing pollution. It is reported by the Council of European Union (2015) that Italy has estblished , National Energy Strategy (NES) targets which focuses on year 2020 short-run targets with long-run targets of 2030 and 2050. Italy joined the Kyoto Protocol, as the other 28-EU countries, and was able to reduce the gap between GHG emissions and Kyoto target from 37.09 in 2008 to -0.87 in 2012[15]. In order to achieve goals of Europe 2020 stratergy Italy started National Reform Programme 2013 which includes three targets; the reduction of GHG emissions; the increase of renewable energy generation; and the increase in energy efficiency (Zane, 2014). According to the Council of European Union report (2015), Italy has established "National Energy Strategy" targets which focuses on 2020 objectives and refers to the long run includes possible scenarios for 2050. This strategy indicates that primary energy consumption will be reduced by 26 per cent by 2050 compared to 2010.

As a member in the European Civil Aviation Conference (ECAC), Italy has the same environmental concerns of the other members which represent a potential constraint on the future development of the international aviation sector. In their report, ENAC concludes that Italy has made significant efforts towards emissions reduction, especially in air transportations and actions related to Clean Sky Program, and by

[15] million tonnes of carbon dioxide-equivalent ($MtCO_2$-eq)

2050 it is expected to achieve 40 per cent improvement by using efficient technology (ENAC, 2012). The development of the Italian National Energy Strategy (NES) puts meeting environmental targets as a apriority and a clear goal to be achieved; for example the long run shift in the power sector by reducing the share of oil in the electricity generation mix from 51 per cent in 1995, to per 5 cent in 2015 (IEA. 2016).

According to the country report done by the researchers at Ecologic Institute (2014) Italy has strategic policy with an emphasis on "green growth" elements regarding economic improvement in the energy sector and The 2020 target non-ETS emissions reduction target. It is interesting to mention that Italy uses different energy mix from the one used by the rest of 28-EU countries; the natural gas plays an important role with share of 36 per cent of total Italian mix in 2013 (European Commission 2015)[16]. However, some other studies called for a more a comprehensive strategy to reduce transport CO_2 emissions in Italy (Noceraa & Cavallaro 2011). While others believe that the global warming is unavoidable even if Italy was able to reduce carbon emissions, moreover**,** they claim these emissions may have positive impact and could benefit the agriculture sector by the carbon fertilization effect (CFE)[17] (Carraro & Sgobbi, 2008).

However, it is claimed by others that environment issues in Italy have less priority to the government compared with other European Union countries. And Italian policy still is not quite clear towards cutting CO_2 emissions. It is stated by the European

[16] For the relative importance of Italy as the main trade partner for Libya, we give more discussion for Italian energy consumption in chapter 3 as well.
[17] A larger amount of carbon dioxide in the atmosphere would increase the plants growth, which use carbon dioxide during photosynthesis, and increase crop yields.

Environment Agency (EEA) the picture of Italy in tracking progress towards EU Member States' climate and energy targets, is not clear yet (EEA. 2016). And it might be a challenging task for Italy to meet the requirements of Europe environmental strategy for 2020 (Annicchiarico, 2014). That the decision regarding the environmental commitment is affected by several factors including political and business policy, besides, the domestic lack of awareness (OECD 2013).

Its claimed that Italian policy is the missing comprehensible plan to reduce carbon emissions (Virdis, 2015). Another critique to the environmental policy in Italy is that there is no explicit carbon tax within the environmental tax, and no indication to emissions level or their impact in transportation sector (Edoardo B. Zane 2014).

Therefor and as a result of the fact that Carbon dioxide represents the largest share of GHG emissions and because it remains one of the main sources of environmental harms, it is essential to inspect the changes of these emissions and examine the fundamental relationships between environmental pollution and economic growth.

Therefore it is important to explore the environmental policy in Italy by evaluating the environmental degradation represented in our study by emissions of per capita Carbon dioxide. In this regard convergence of CO_2 emissions must be attained to fulfil environmental concerns appeal. Therefore, the empirical part of our research includes investigating the convergence of CO_2 emissions in European Union and environmental policy in the Italian economy is included in chapter 4 also to explore the potential important natural gas suppliers in the region; more specifically more focus on Libya as a main partner for Italy.

3.5 The Importance of Natural Gas Trade from Libya

In our study we believe that Libya has the potential to be a key exporter for natural gas in the region. This will be discussed here and further discussion in the next chapter.

In natural gas market, the pressure on both side of supply and demand is showing an upward trend. The natural gas is considered as a sustainable option in the long-term in Europe. Therefore, to cover the gap of natural gas demand beyond 2015, Europe needs to seek further resources to import natural gas from alternative sources (Bonhomme, 2013). If the trend of the reduction in Europe's domestic gas production from existing fields keeps continues as it is, in addition of reducing its imports of high cost LNG that would unquestionably persuade the needs for Europe to improve its energy structure by constructing new pipelines to reach alternative natural gas sources. It can be argued that there is emerged need for Europe to get other alternative source of natural gas not from Russia which is already high-priced with a condition of long-term contracts, but alternatively from Libya who has a significant gas potential at a lower and with hub determined spot prices. It is then Libya can play an important key role in natural gas export to Europe[18].

Adding to our consideration the new discoveries in 2015; investments in natural gas exploration are expected to increase Libya's proven gas reserves in the near future. Furthermore, with speculations about Egypt to lose this position due to aggressive increasing domestic demand (Stern, 2015), hence, Libya can be seen as second biggest natural gas exporting country to Europe within North Africa region.

[18] More regarding the Libyan natural gas is discussed in the next chapter.

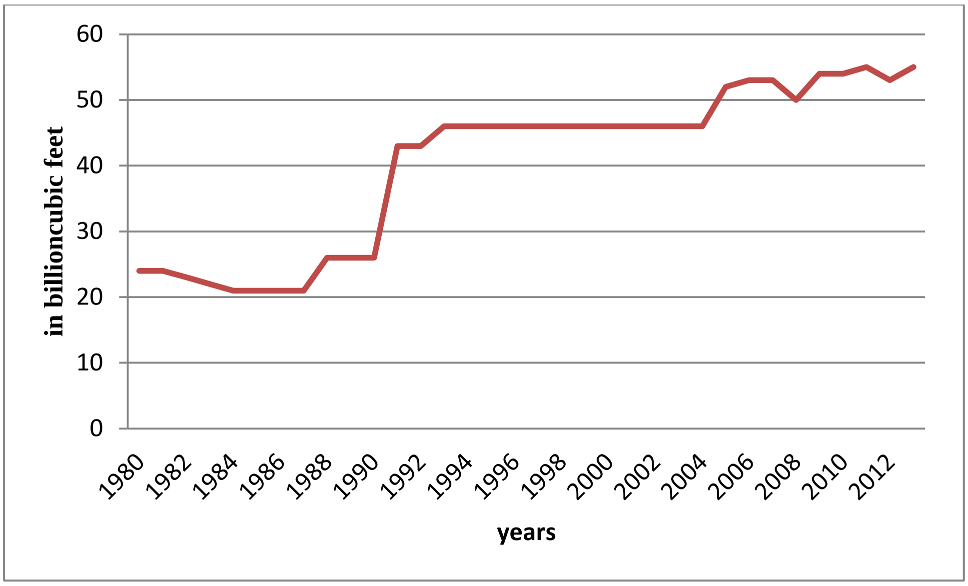

Figure 3.6: Proved Reserves of Natural Gas in Libya

Libya has noteworthy prospective position in future natural gas market; given its production, exports and proven reserves for more than a decade. As can be seen from Figure 3.6 the Libyan natural gas reserves has been steadly growing during most of the period of the last decade. Exports have increased during the period of 2000-2013 with a growth rate of 48 per cent in average with stable reserves amounting 1,505 bcm in 2017. It is stated that EU countries are net importer of natural gas, and progressively relying on limited suppliers for natural gas, where the share of Algerian natural gas is 18 % (K. Talus, 2011). Accordingly, as a country, closely, located to net importer of natural gas as EU, Libya should be considered as important promising supplier in a strategic position to Europe.

This persuades the idea of how much potential that Libyan gas could have. This could enhance Libyan natural gas trade and make it play a game-changer role in the Mediterranean market. While one major decision some countries have to be worried about that whether to conserve its natural gas reserves in gas fields for future domestic consumption, or to implement a project for exporting natural gas, Libya, by contrast, has no reason to face same struggle to make such a decision that is because of its reserves comparing with its consumption as discussed in previous sections.

In the next chapter we review the Libyan natural gas sector discussing the main advantages and challenges in this regard.

Chapter 4

AN OVERVIEW OF LIBYAN ECONOMY AND GAS INDUSTRY

The Libyan economy, mainly, depends on the revenues from hydrocarbon exports. It essentially relies on oil sector; IMF reports reveal that more than 95 % of export revenues come from hydrocarbon industry. That makes the country vulnerable to any instability in the international oil market, therefore, the country's economy needs to be less dependent on oil exports to achieve the diversification goals of the economy and also increase the oil reserves. This can be accomplished by focusing more on gas sector; especially that Libya has huge proved reserves that can cover the domestic and international demand both in medium and long term. This will be discussed and analyzed by surveying the developments taken place in natural gas sector and the potential and possibilities that Libya has in this regard. In addition to these issues the need for the government and policy makers to improve Libyan position in natural gas market as net exporter to Europe, and also the significant factors which support this argument will be discussed in this chapter. In soquel of this chapter an overview of Libyan economy, more specifically the gas sector, production of natural gas, proved reserves and current and potential exports to Europe we be reviewed. Also, the existing natural gas and LNG[19] fields and pipelines

[19] This study mainly focuses on natural gas leaving deep analysis for LNG in Libya for further study in future.

structure and the challenges that may face natural gas sector in Libya will be reviewed.

4.1 Libyan Economy-General overview

Libya is one of the largest countries in Africa with area of 1,759,540 km^2, with population of about 6.374.616 million, and GDP per capita 7,998.03$ (2017)[20]. However, its oil revenues and small Libyan population lead Libya to be the highest nominal per capita GDP country in Africa which we believe is really a misleading indicator in terms of low living standards for people and diminished infrastructure that many Libyan cities suffer. Libyan economy is primarily, based on the oil sector, where 95 % of the country revenues are from energy sector exports this refers to 80 % of the GDP and 99 % of government income. The economic growth in Libya was held back by many factors including the regime that has been in control for the last 4 decades and the UN sanctions; specifically UN Resolution 883 of November 11, 1993 until it is completely lifted in 2006. Due to the one-man-state control regime private investment and foreign direct investment were indeed modest. International sanctions, had severe impact on the economic development; for instance, forbidding Libya from importing any advanced technology such as refinery equipment and necessary equipment needed to upgrade natural pipelines, leaving the main energy sector behind any progress, in fact these are the main factors behind the slow growth in Libyan economy.

Libya has a growing demand on electricity. It was estimated by the World Bank that about 99.8 % of Libyan population had access to electricity, and due to the increasing demand on electricity it was doubled in the period of (2000-2010). Natural

---

[20]. World Bank statistical data.

gas in Libya has gained importance as a source for energy, and several power plants were adjusted to natural gas instead of oil seeking lower costs and currently its share is about 45 per cent of the total energy. As a result, this is an additional motivation for Libyan policy makers to increase the production of natural gas and use it as electricity generator among their strategy of economic recovery to release oil for exports[21].

Libya is a member of the Organization of Petroleum Exporting Countries (OPEC) since 1962. Currently Libya holds the largest amount of proved crude oil reserves in Africa, is ranked as the fourth largest amount of proved natural gas reserves, and it is a significant provider to the global supply of light, low sulfur crude oil to Europe as the main trading partner.

According to the international statistics Libya began exporting oil in 1961[22]. In 2015 Libya holds proven crude oil reserves around 48.4 billion barrels, total production of oil was about 1.8 million barrels per day, the oil exports earnings have the main contribution to the GDP. While the natural gas production and exports of natural gas remain modest comparing with oil sector in spite of the massive proved reserves of natural gas that available in Libya.

In addition to being the largest holder of proved crude oil reserves in Africa, Libya is a significant holder of natural gas reserves. Libya is ranked as the fourth largest

[21] However, to achieve stable increase in production of course require an improvement in security environment; the strong economic recovery in 2012 due to energy sector activity continued to be held back by the uncertainty; for example the frequent strikes by militians at oil and gas fields made severe disruptions in oil and gas production units starting in 2013, causing a reduction of both oil and gas exports and resulting a drop in government revenues as well.
[22] www.opec.org and World bank, country report, oil and gas journal (O&G), and https:knoema.com; atlas/Libya

holder of proved reserves, indicating a potential for Libya to be a strategic supplier in the region and a possible key role for Libya and encourages Libya to compete with other suppliers to Europe. Libya could have more chance comparing to other competitors. For instance the increase in domestic consumption due to rapidly growing domestic demand in Algeria and Egypt, which restricts the availability of natural gas for exports in future in these countries. Moreover, Libya has advantage in terms of transection costs. This is because of exporting natural gas from Algeria to Italy via Tunisia as country transporter makes it less attractive in terms of transaction costs compared with importing directly from Libya.

4.2 Energy Sector in Libya

The Libyan most significant natural resource is its petroleum. Beside that Libya has natural resources other than petroleum including natural gas and gypsum, but oil sector remains the main source for funds. The proven oil reserves that Libya holds make it the largest oil holder country in Africa. Libya has a successful history of oil and gas exploration mainly in the Sirte basin; which covers area of 172000m^2 in central Libya which recognized as the most productive hydrocarbon basin in North Africa contains giant gas fields has yielded 33 Tcf discoveries[23]. The World Bank statistics show that the natural gas rents 2.5 percent of GDP in 2013 and 3.16 in 2014 where the highest value in the past 24 years was in 2008 was 6.05percent of GDP[24]. Libya has huge volumes of proved reserves which enhance possibility for Libya to play a significant role as exporter of LNG and natural gas in its reign. It is reported that Libya has the potential produce gas for at least a hundred years ahead, this is due to its gas reserves/production ratio which is more than 100 (Mac Donald, 2010).

[23] (EIA world shale gas and shale oil resource assessment 2015).
[24] Natural gas rent = the value of natural production at world prices - total costs of production. (databank.WorldBank.org).

However, Libya still has a modest natural gas share in exports. Libya exports the majority of its natural gas to Europe in addition of meeting the domestic demand, this sustains the need to discuss that and how more appropriate and interesting to revise Libyan's natural gas issues.

4.2.1 Libya's energy consumption

As been affected by the U.S.A and International sanctions for many years energy sector was impacted profoundly, and the plans for development to this sector as a result were limited. Nevertheless, domestic energy consumption is growing and predicted to keep increasing (MacDonald, 2010). As shown in Figure (4.1) natural gas is just 28 % of total energy consumption to fulfill energy domestic demand in Libya. And as a resource of energy, as we can see in Figure (4.2) that natural gas generates about 45 % of electricity.

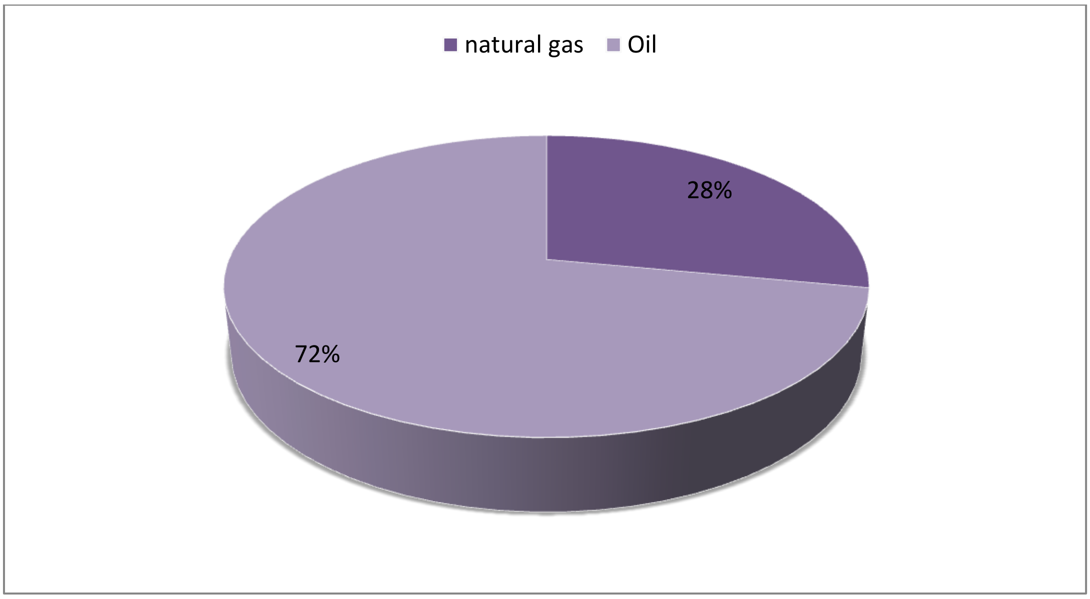

Figure 4.1 Libyan Total Energy Consumption.

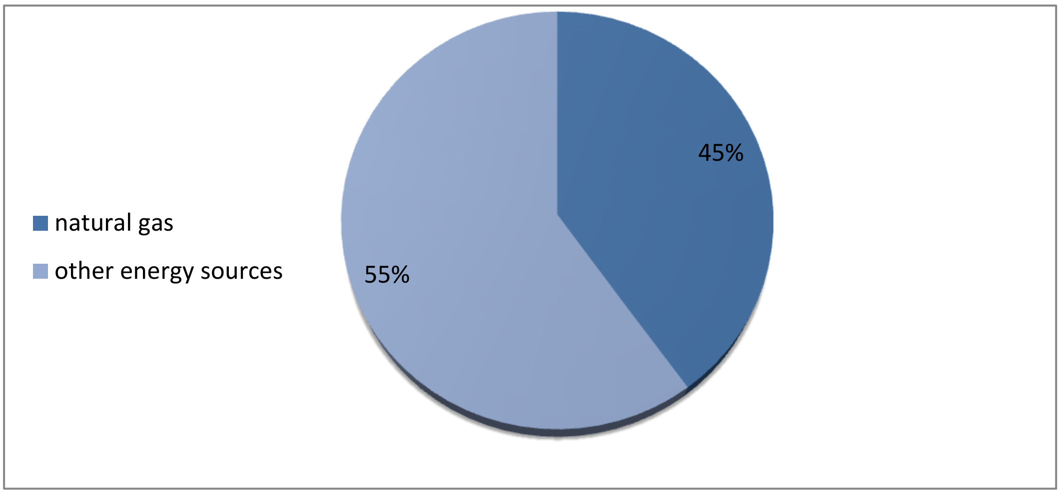

Figure 4.2: Natural gas as electricity generator

As shown in Figure 4.2 natural gas generates about half of total electricity produced which we believe that it is far from it should be. The fact that the electricity sector is 45% powered by natural gas means it remains humble sector in the domestic energy market. This enhance the idea of depending more on gas to generate electricity to use some of enormous reserves of natural gas that Libya has in order to diverts power sources and national income at same time. In recent years there were attempts to depend more on natural gas to power Libya's thermal plants in order to release more oil availability for future exports, though, these attempts did not become reality yet. However, the International Energy Agency (IEA) prediction of an increase in domestic consumption as much as 50 percent, if real steps are made toward activating the plans for projects to increase natural gas use for electricity generation, infrastructure planned pipelines and gas-fired power plants.

4.2.2 Libya and the Natural Gas Market

Despite being a significant promising exporter for natural gas to Europe, Libya has not received an adequate attention as a gas exporter. Libya ranks as a producer and reserve holder, but still less significant than Algeria in the natural gas market, although it has proven massive reserves of natural gas which could drag the attention of the International Oil and Gas companies. Therefore, Libya has the potential to be a key country as natural gas supplier to Europe. Up to the current time, Libyan natural gas totally exported to Europe, and Italy is the main destination which imports natural gas from Libya via pipelines. Moreover, Libya is planning to increase the production of natural gas in offshore and onshore fields with progressive intention to utilize natural gas instead of oil due to Europe's de-carbonization issues. And so the increase natural gas production would probably lead to a larger use of natural gas in the power sector and thus release more oil for export. The new future plan is to maximize the amount of gas output to be non-associated fields while the production of associated reservoirs is expected to decline gradually. These plans anyway are still vulnerable for security issues and need to lower level of uncertainty.

The energy sector has some recovery after sanctions were left, in 2003-2004. Numerous foreign investors and firms try to rescue their businesses, including U.S. companies Petroleum and consortium partners. The production and the exports of natural gas in Libya has increased significantly since lifting UN-sanctions with the developments of some new projects such as, the Western Libya Gas Project and the opening of the Green-stream pipeline to Italy, which will be discussed in the coming sections.

There are some of international energy companies explore, operate, produce and transport natural gas, such as Eni, BP, Shell, ExxonMobil and others, but Libyan natural gas industry is mostly owned and operated by the state, International companies participate in exploration, production, and transportation of natural gas.

4.2.3 Production of natural gas

In spite of huge proven reserves of natural gas in Libya, natural gas did not get enough attention what it is worth. The existing gas projects still remain largely underdeveloped, and many explorations need to be done in this sector. The marketed gas output, mostly onshore, has associated to oil production; moreover, considerable quantity is believed wasted.

However, Libya has limited level of domestic consumption of its locally produced natural gas and expected more production in the future, which would be reflected in an increase in its natural gas exports capacity. Hanfer and Tagliapietra (2013) have reported that Libyan domestic gas consumption is low (8.7) bcm, due to Libyan small population, and predicted to be about 14 bcm by 2020, and the exports potential is predicted to reach (19) bcm by 2030. For instance, even before the uprising events and comparing with its proved reserves Libya's natural gas production is still believed that it is at lower levels than should be. Libyan production of natural gas in 2009 was 1,034 billion cubic feet (Bcf) and exported 562 Bcf. It is stated that Libya has export capacity of 12.5 bcm to Europe with a potential to be increased in future to 40 bcm (Mac. Donald, 2010).

4.2.4 Proved Natural Gas Reserves[25]

One of our main motivations to predict a significant role for Libya as net natural gas exporter is its proved reserves. Libyan proved reserves of natural gas are about 54 trillion cubic feet, although the period between 2004 and 2015 witnessed a dramatic increase in production of natural gas, the reserves remain stable during last decade. With reserves to production ratio above 100 Libya has the ability to produce gas not

[25] Proved reserves are the estimation for the gas quantities that are recoverable under existing economic and operating conditions.

less than 100 years with output level of 10 bcm with potential to increase production to 16 bcm per year (Mac.Donald. 2010).

Estimated by Central Intelligence Agency in 2017, Libya's proven natural gas reserves are 1505 trillion cubic meters, in comparison with the world, Libya's proved reserves ranked twenty-second, the fourth in Africa and the third in North Africa[26], Figure 4.3, represents top holders of proved natural gas reserves (in trillion cubic meters) in North Africa in 2017.

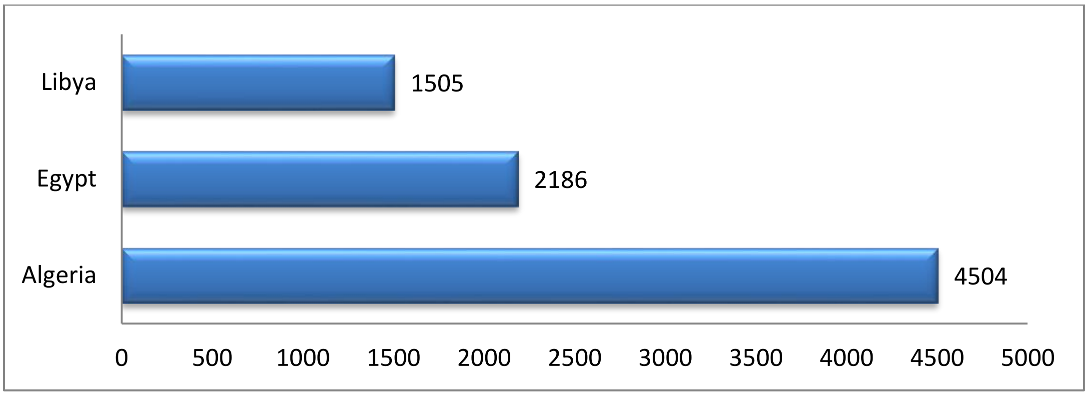

Figure 4.3: Top holders of proved natural gas reserves (tcm) North Africa

While some countries have to be worried at making a decision on whether to conserve its natural gas reserves in its gas fields for future domestic consumption, or to implement a project for exporting natural gas, Libya, as discussed in previous sections, has no reason to face same struggle to make such a decision. That is due to its reserves comparing with its consumption. According to estimations of Oil and Gas Journal (2013), Libya's proven natural gas reserves were 54.6 trillion cubic feet, making it the fourth largest natural gas reserve holder in Africa. In addition to the new discovery in 2011; investments in natural gas exploration are expected to increase Libya's proven gas reserves in the near future. And with speculations about

[26] (1 cubic foot = 0.0283168466 cubic meters)

Egypt to lose this position due to aggressive increasing domestic demand, Libya can be seen as second biggest natural gas exporting country to Europe within North Africa region.

Natural gas exports in Libya are about 1.7 times the domestically consumed natural gas. The consumption of natural gas in Libya is reported at 212 Bcf and the exported is 349 Bcf of natural gas to Europe and mostly by pipeline to Italy and a minor volume in the form of (LNG). The libyan natural gas proved reserves are about 1,506 trillion cum. Since 2004 Libyan's natural gas exports mainly to Italy are about 93% of total natural gas exports. The Libyan natural gas is piped from the Wafa concession and the offshore Bahr Essalam fields to Mellitah, then treated for export. As shown in (Figure 4.4), since 2004 natural gas exports to Europe have grown substantially during period ot time and exported by the Greenstream pipeline from Mellitah to Gela in Sicily.

Table 4.1: Proven Natural Gas Reserves (Billion Standard Cubic Meters)

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1,314	1,314	1,503	1,491	1,491	1,491	1,420	1,539	1,539.5	1,549	1,495	1,547	1,549	1,506

Source: Prepared by authors from http://www.opec.org

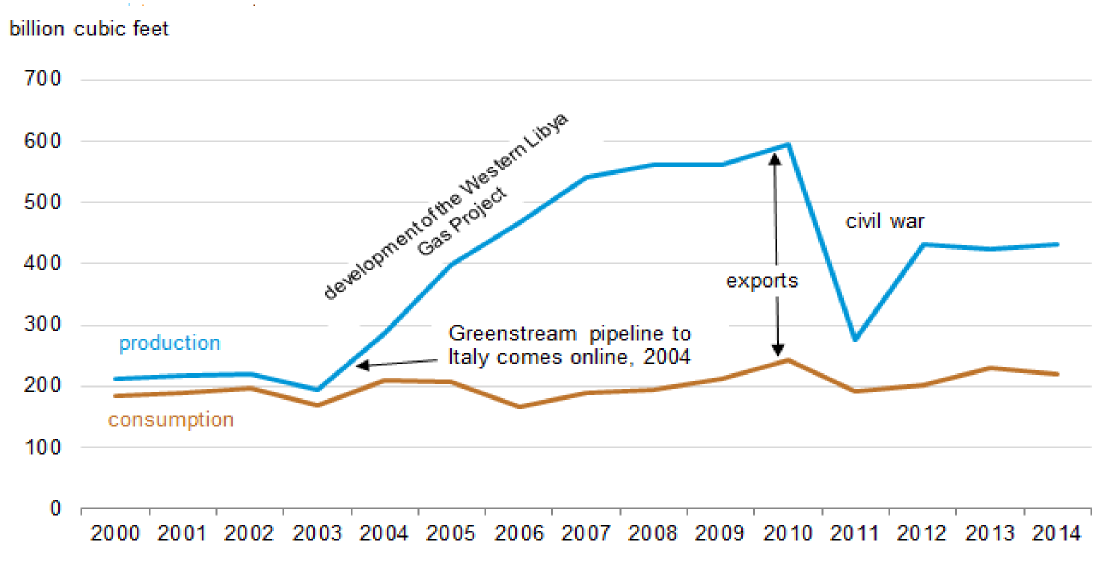

Figure 4.4: Libya's Dry Natural Gas Production, Consumption and Exports (2000-2015).

As can be seen from Table 4.1, the sustainability of Libyan natural gas reserves has been increasing which causes an argument how Libyan gas potential in natural gas market could play a game-changer role in the Mediterranean.

As shown both in Table 4.1 and Figure 4.4, Libya has high potential in exporting natural gas. Exports have increased during the period of 2000- 2013 with a growth rate of 48% in average with stable reserves amounting 1,506 bcm. In 2014 the consumption of natural gas was about 221 Bcf, about the half of total production, and 211 Bcf was exported to Italy, the rest is consumed domestically.

4.3 Liquefied Natural Gas (LNG)

Although the natural gas piped is the main scope of this study, it is important to explore the impact of liquefied natural gas (LNG) trade for Libyan economy. With a simple comparison between the methods of exporting natural gas, pipelines remain the dominant mode of transportation of natural gas. Patsev et al (2013) have reported that natural gas exported over the world was 68 percent of internationally traded natural gas and in the same year pipeline imports accounted for about 59 percent of this traded natural gas to Europe that is roughly 40 per cent of total European gas needs (Bonhomme, 2013)**.** This might be due to several advantages of piped natural gas which has more than LNG. For instance, the relative lower costs and investment requirements in comparison also matters with LNG.

LNG in Libya was mostly exported to Spain, and Libya ranked the third in the world, after Algeria and Russia. The sole LNG plant in Libya, in Marsa al-Brega started in the beginning of 1970's with a designed capacity is 3.2 million tons (154 bcf/y). And this capacity was planned to be increased to 4.3 bcm/y (Hafner and Tagliapietra 2013). Also, a second LNG terminal is being planned in Mellitah. But practically exports was around less than (1/3) of this capacity. This is due to the lacks of the necessary needed technology, which affected by UN and USA sanctions as mentioned before, also, the focus by government was always on oil exports rather than develop natural gas fields. Nevertheless, the LNG plant was negatively impacted by the political unrest and as a result affected exports of LNG. However, the actions involved with Feb 2011 have limited effects on energy sector especially with the significant recent discoveries. It is seemed that Libya's petroleum infrastructure has emerged relatively unscathed from the conflict (Vandewalle, 2011).

However, LNG revolution continues to be an interesting topic for us as future study we plan to do for LNG sector in Libya especially with the influence of the global liberalization of the natural gas industry.

4.4 The Importance of Libyan Natural Gas to Europe

Libya can play a key role in European natural gas market. This claim could be attributed to a number of reasons; firstly the opportunity for Libya to fill the gap in the market, due to the tensions between Russia and Ukraine which leads to European Union searching other suppliers for their need of natural gas, therefore there is need for revisiting Libyan role in natural gas market. Secondly a more appealing source for concern is the huge proved reserves of natural gas that Libya has. This drives the consideration towards exporting more natural gas and depending more on natural gas to produce electricity to satisfy the local demand as well so, more oil can be released for exporting.

One of the most significant indications in our analysis is the obvious increase in the proven reserves in addition to the newly discovered sources of natural gas in period of 2011 and 2015. The rapid rebuilding estimates of natural gas reserves, which had been steadily increasing, draws the attention of policy makers to the fact that natural gas is a major and critical key in the energy stability of national economy. Moreover, another advantage Libya has is that the geographical position of Libya being close to active demand for gas in the European market makes her an important potential exporter of natural gas. Therefore Libya has the potential in natural gas market and can play a significant role as natural gas supplier.

4.5 Italy as a Hub for Energy to Europe

Gas is maintaining its significant position as energy source. It is the major contributor to total primary energy consumption and considered the right choice for heating in Europe, as first costumer's choice[27]. Realizing the importance of gas for

[27] Eurogas, Marcogaz and GERG, Report, Sep, 2014.

Europe, it is mandatory for European countries to seek the most possible gas suppliers in the region, as seen in Figure 4.5 gas still dominates the energy sources in Italy and EU countries. Recent studies show that the demand for gas is expected to growth in the next decade and a large part of this contributed to power sector (IHS, 2016). It is predicted that demand for gas will raise leading to a significant increase in gas imports in Europe to about 190 billion cubic meters (bcm) in the next two decades. And Italy is the second largest natural gas importer after Germany which imports 25 per cent of imports to Europe[28] , therefore, due to Italy's location between one of the largest holders of proved reserves of natural gas, Libya, and largest natural gas importer in EU, Germany, Italy can play a key role to supply gas to northern Europe by importing gas from suppliers in south Europe. This emphasizes the possibility of Italy to be as hub of natural gas by linking Libyan natural gas exports to European market.

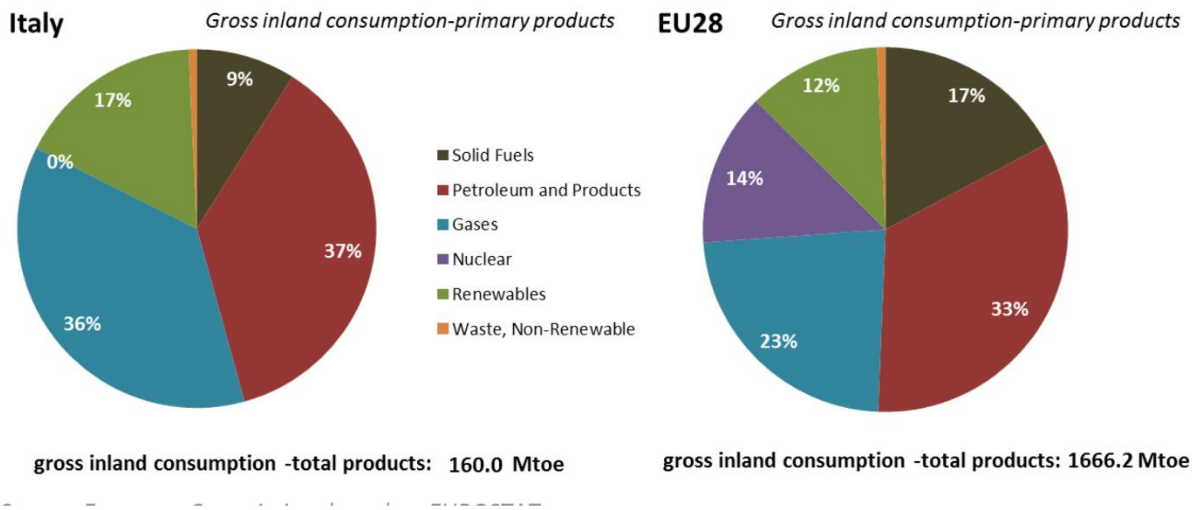

Figure 4. 5: Gross inland consumption-primary products of Italy and the EU

[28] World Bank, https://wits.worldbank.org/countrysnapshot/en/DEU/textview

4.5.1 Natural Gas in Italy

According to World Fact-book (2016) and World Energy (2017), Italy is one of the top 10 countries in the world and the second in Europe in consuming dry natural gas, and the fourth in the world regarding the gas imports; accounting about 64.5 million cubic meters. Figure 4.6 represents natural gas consumption in Italy during last decade; it shows the increase trend in Italian consumption except a slight decrease in 2014 then increased again.

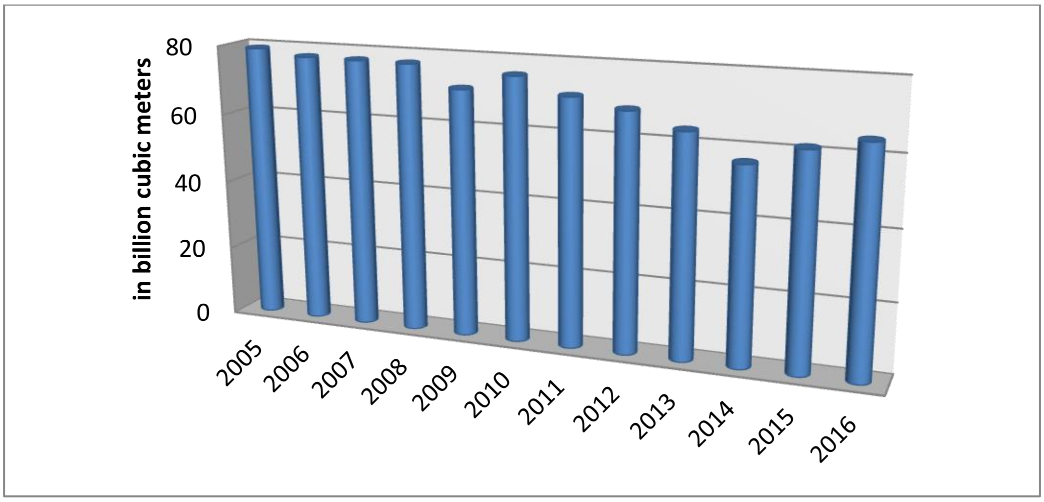

Figure 4.6: Natural Gas Consumption in Italy: 2005 – 2016

It is worth noting that, being close to both Libya as net supplier and Germany as net importer for gas, backups the idea of Italy as hub of natural gas by linking Libyan natural gas exports to European market. Specially, after rising concerns of high proportion of imports among few limited suppliers; Russia, Norway and Algeria, this put security of natural gas supplies at centre of attention of European countries.

Natural gas is the predominant source among other energy sources in Italy. Even though with increasing usage of renewable sources, natural gas still the most common source of electrical energy, and the largest fuel in energy sector as a whole in Italy[29]. Fossil fuels are the major contributors to energy generation, accounting about 60 per cent of total electricity generation in 2015; and natural gas has the main share of this contribution (IEA, 2016). Figure 4.5 & 4.7 show the natural gas as the predominant source among them; it accounted for 38,3 per cent of the total power produced, the share of gas was more than 64 per cent compared with other fossil fuels, coal and oil 16.6 per cent, 4,8 per cent respectively.

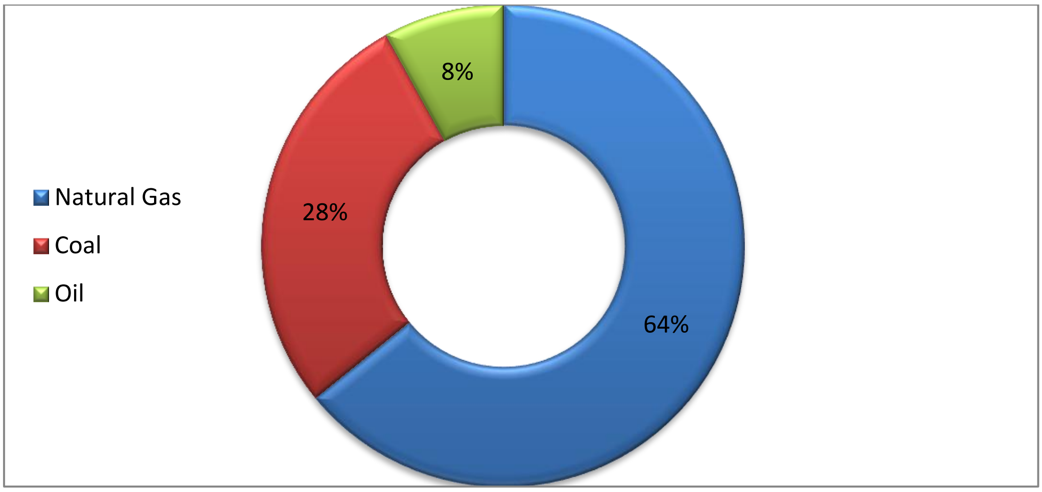

Figure 4.7: Fossil fuels sources of electrical energy in Italy in 2015.

Currently the main supplier of Italian natural gas is Russia; 51 per cent of natural gas imports in Italy come from Russia via entry point of Tarvisio and Gorizia, then Algeria and Libya comes after as major suppliers for natural gas to Italy via entry point of Mazara del Vallo and Gela and then distributed to the Italian main land.

4.6 Libyan and Italian Energy Partnership

There is long-term strategic partnership had taken place for more than 5 decades between Italy and Libya. Italy is considered the top destination for Libyan natural gas exports. Libya is seen by Italian energy companies, especially Eni[30] as a vital

[29] The International Energy Agency (IEA) 2016.
[30] Eni is Italian oil & Gas Company and the largest foreign oil and gas producer in Libya since 1959.

energy partner, even during the uprising events in Libya; Eni still continues on exploration and developing natural gas fields in Libya. According to Eni and National Oil Cooperation (NOC)[31], Eni Company made new two discoveries of natural gas in 2015, in Area D at an exploration off the Libyan coast140km offshore from Tripoli.

Italy is considered the main trade partner for Libya. In 2015, more than 50 per cent of Libyan exports was to Italy and imports were about 14.5 percent from Italy including crude oil, refined petroleum products, natural gas; in values Libya exports to Italy ($4.46 Billion) which makes Italy number one Libyan trade partners, and Libya imports from Italy ($1.65 B) places Italy second after China. In addition, Italy is the largest importer for Libyan natural gas; accounting 13 per cent of total Italian imports of natural gas, but, this partnership was more significant before uprising 2011. According to ENI, recently, there is a project to increase supply for natural gas from Algeria via new pipeline (GALSI) to Italy via Sardinia and anticipated to be complete in 2018. Nevertheless, it is interesting to point out here that the reserve to production ratio of Libyan natural gas is more than 100 years while in Algeria is just 57.3 years (Stern 2014), therefore, it is important to high light how crucial for Libyan policy makers to face this competition in gas market, and make Libya more attractive than other options for the long term partnership. However, when political issues are settled down, Libya is considered closer country to Italy than Algeria and Russia without any need for transition country, implies lower costs of gas transporting to Italy.

[31] NOC is the National Oil Corporation in Libya.

4.6.1 Main Libyan Projects to export Natural gas to Italy

The major project to export natural gas from Libya to Europe is the Western Libyan Gas Project (WLGP) which started in 2004; and operated by ENI and the NOC through the Mellitah Oil and Gas joint venture, WLGP includes onshore Wafa field and offshore Bahr Essalam field. WLGP project created a huge change in natural gas industry in Libya, since then Libya's production and exports increased significantly, as presented in Figure 4.4 where natural gas exports as the difference between production and consumption during the period 2000 and 2014, shows a huge increase in 2003 and deep decline in 2011 during political unrest, the production raised substantially from 194 billion cubic feet (Bcf) in 2003 to 594 Bcf in 2010, most of this production is exported via Greenstream pipeline to Italy.

The Greenstream pipeline is a natural gas offshore (submarine) pipeline project running from Libya to Italy (Mellitah to Gela) which is one of the most important projects in Western Libya. The Mellitah Gas Compression Station also owned by Greenstream on the Libyan coastline. This pipeline has been in use for many years to export Libyan natural gas to Italy through crossing the Mediterranean Sea from the Wafa area in the Libyan Sahara desert. Greenstream is an Italian company owned by Eni SpA and (NOC). The Libyan State Company owns and operates the Mellitah Gas Compressor. The Greenstream pipeline which runs from Mellitah to Gela (Sicily) has been operative since 2004. An onshore connection for gas pipeline between Mellitah and Gabes (Tunusia) was projected with a distance of 266 km long with an initial capacity of 2 bcm per year. But as Hafner and Tagliapietra (2013) pointed out, there is still no certainty about this project, and no real progress has been made and the future of the project is dependent on the Libyan government guaranteeing the gas supplies. The Libyan gas export capacity is expected to reach up to 15 bcm by the end of 2020. Libya's vast gas reserves and current explorations with new proven reserves in the Sirte Basin, could easily increase Libya's future gas export potential to Europe up to 19 bcm per year by 2030.

Table 4.2 Main Gas Pipelines in Libya

Libya	**Owner or Operator**	**Length**	**Capacity, width**
Wafa / Mellitah (2)	Mellitha Oil&Gas	2 x 326	16, 32
Bouri Offshore / Bahr Essalam (2)	Mellitha Oil&Gas	2 x 12	4, 10
Bahr Essalam / Mellitah (2)	Mellitha Oil&Gas	2 x 68	10, 36
Mellitah / Gela (Italy)	Greenstream	334.8	32
Attahaddy / KM-91.5 (2)	Sirte oil	2 x 16	12, 30
KM-91.5 / Brega (2)	Sirte oil	2 x 57	16, 36

Source: OPEC's annual statistical bulletin (2014)

4.7 The potential and the challenges: Current and prospective view

Libya has characteristics that increase the potential for Libya to be significant net exporter for the natural gas in the region. The Libyan coastline has many advantages which make importing natural gas from Libya attractive economically more desired.

A part of exploring how it is sufficiently worthwhile to import natural gas from Libya, a discussion is needed for the characteristic of Libyan natural gas compared with other options in the region. In this regard in terms of reserves and geographic features it seems that Libya has a unique potential; the Libyan coastline is shallow and flat free of hazard, earthquakes, which makes importing natural gas from Libya fiscally more attractive with lower risk (Macdonald M. 2010). Besides that, extracting natural gas from Libyan onshore and offshores are relatively cheaper due to lower costs. It is stated by Hafner and Tagliapietra, (2013), that Libyan natural gas will have more competitive prices comparing to the other nations in the region, such as Algeria and Tunisia. Moreover, the transportation costs of Libyan natural gas are the most economical option for many demanders. In addition, gas tariffs is another reason that discourages imports from Algeria to Sicily Italy and Malta; the extra costs induced by tariff to import from Algeria and Tunisia make it more expensive compared to the option of directly import natural gas via Libyan pipeline, adding up the shaky credibility of gas company in the past few years[32]. According to Mac Donald report (2010), Libyan natural gas can be delivered at a cheaper price than other neighboring nations due to closeness to European countries such as Italy and Malta.

It has been proposed that building new natural gas pipelines in Libya to south European countries such as Malta, Italy, Spain and even Greece would secure European gas demand at least for another couple of decades (Hafner & Tagliapietra, 2013) and Mac Donald, 2010)). Their work and the study by Manuel (2011) all support a greater role for Libya in gas market in future. Considering the Libyan position in the Mediterranean neighborhood and geographical features, having the current limited production levels of natural gas supply with enormous reserves that

[32] Sonatrach continued to be affected by the 2010 corruption has struggled to raise production in the aftermath of a corruption Allegations in Algeria in 2010, www.Bloomberg.com.

Libya holds, it would be reasonable to encourage Libyan authorities to build new pipelines for the needs of European countries[33].

Therefore, in the light of the previous discussion of the huge reserves of natural gas that Libya holds with the modest domestic demand for a small nation, not to mention new exploration by Italian Eni Company, also the new development for the existing natural gas project, which could increase the possibility for more production of natural gas in future, thus predict a bright future for Libya as a net exporter to Europe especially for Italy.

Besides that, extracting natural gas from Libyan onshore and offshores are relatively cheaper due to lower costs. It is stated that Libyan natural gas will have more competitive prices comparing to the other nations in the region, such as Algeria and Tunisia(Hafner & Tagliapietra, 2013). Considering the current shale gas findings in the US (North Arizona) and Mozambique, the price of natural gas has become more competitive in some of the spot markets, such as Henry Hub and is currently in the range of USD 2.5 to 4.0 per MBtu. The transportation costs of Libyan natural gas could be the most economical option for many demanders. For example the extra costs induced by tariff to import natural gas from Algeria and Tunisia makes it expensive compare to the option of natural gas with Libyan pipeline. According to Mac Donald (2012), Libyan natural gas can be delivered at lower cost than other suppliers in the region. Gas tariffs also, is another reason which discourages imports from Algeria to Sicily Italy and Malta.

[33] With the lack of making the right policy decision the market forces will not optimize the economic benefits for Libyan economy; therefore, there was a need to do such studies for developing natural gas sector in Libya.

Table 4.2 shows the main gas pipelines in Libya. However, it has been proposed by some academic scholars, such as Hafner and Tagliapietra (2014) and Macdonald (2012) that building new natural gas pipelines to south European countries such as Malta, Italy, Spain and even Greece would secure supply for the European gas demand at least for another couple of decades. This proposal is due to Libyan position in the Mediterranean neighborhood and the geographical features that encourage Libya to build new pipelines for the needs of 532 million population of EU-28.

In this study a feasibility study is needed for evaluating the existing pipelines at the designed capacity constructed with before doing any evaluation for new pipelines to export natural gas from Libya to other destinations in the Mediterranean. This is important before examining the validity of the suggestion for the need to expand the current gas pipelines and diversifying future natural gas projects with additional LNG terminals, which initially motivated by the limited production of natural gas supply, with presence of the huge amount of proved reserves. This purpose will be met in chapter five of this research; for this purpose a feasibility study is done for natural gas pipeline exporting natural gas from Libya to Italy in next chapter.

4.7.1 The Impact of International Sanctions

In spite of the fact that Libya is the fourth largest state in Africa which is emerging as one of the major markets for many desired economic activities and energy projects, the international sanctions were the most difficult barriers faced the energy sector in Libya during the period of more than two decades. International sanctions, from the 1980s to 2003, implied that Libya was banned to import certain oil production equipment and new technologies, which were crucial for the energy sector. During this period, oil output at several fields dramatically declined and, subsequently, natural gas industry left behind[34]. It is worth to be noted here that, in any study- regarding Libya- to take into account the results of imposing sanctions by the United States and the United Nations, which have had profound impacts on the whole economy of Libya. This is in particular, damaging the existing Libya's hydrocarbon production and exports projects, and has presented considerable obstacles to achieving many economic reform plans.

4.7.2 The political instability in Libya and economic development

At the beginning of 2011, Libya has experienced political unrests which leaded to a down turn in the economy. Due to political instability, oil and natural gas exports reduced, in addition of the decline in oil prices within the same period resulted in reduction in GDP growth was 41.8% in 2011(African Economic Outlook, 2012)[35].

On the other hand, the same period experienced significant discoveries in natural gas which can impulse dramatic change in this industry, this is in addition of the fact that the revolution, which started on February 2011, has made some steps toward more market-based economy which allowed private investment and entrepreneurial activity that were restrained by the old regime. However, in this study we look at this transition period as another motivation for policy makers , in terms of economy reform, to pay more attention towards natural gas sector to supply domestic and European demand of natural gas.

Security concerns are the main challenge for Libya. Uprising and military confrontation in 2011 have led to disruptions of gas supplies to Europe several times. Resulted less production than previous levels; natural gas production declined from

[34] That is in addition of other factors such as previous regime before revolution of 17 Feb in 2011.
[35] https://www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/ Libya%20Full %20PDF%20Country%20Note.pdf

around 11 billion cubic feet 1068.53 in 2010 to 348.24 in 2011 and 579.52 in 2013[36] then started to increase again. The reduction in the supply created shortage in European gas market, and causing pressure on European countries to seek solutions to meet natural gas needs in order to compensate missing gas volumes (Lochner & Dieckhoener, 2011). However, in spite of the current circumstances that affecting energy sector in Libya, Libya, yet, can still be considered to Italy as superior alternative to other options such as Algeria and Malta[37]; Libya still is seen as a major energy exporter to Europe[38]. Moreover, the foreign gas companies are still having on-going business and compete to have place in future natural gas deals in Libya, as revealed currently by Eni (2017) to have new projects in Libya.

Although the security and safety aspects are the most challenging issues in Libya in the meantime and in spite of security and political instability in the MENA countries, it seems that demand for Libyan oil and gas is unbendable. A good example, is the recent significant discoveries of gas by Eni; the company made its second discovery by the mid of 2015 at Area D in Bahr Essalam field (Figure 4.8), according to Eni these discoveries will increase the potential for Libyan gas in both direction; domestic and foreign gas market[39]. Moreover, considering natural gas exports from Algeria to Masara del Vallo in Sicily with capacity 36.1 bcm per year; which is not directly imported but through transit country Tunisia; Libya sounds money-wise better option. The same can be said about the natural gas coming from Russia through two transit country mainly Austria with capacity 39 bcm per year, especially

[36] World Data Atlas, energy data from http// knoem.com and international energy statistics, Jan. 2016.
[37] Problems related to CS zones between Malta and Italy after the agreement in 1986.
[38] https://www.eia.gov/todayinenergy/detail.php?id=590
[39] This discovery was made in a reserve area is about 85 miles off Libyan coast, 5km north of Bahr Essalam field through the B1-16/4 well, drilled at a water depth of 150 meters which is 110km off Tripoli, will cover the delivery of gas output from C central A area to Sabratha platform. for more see; www.eni.com

with current Russian problem with Ukraine. This raised the appeal for reducing European dependence on Russian Gas (Oxford Institute, 2014). Therefore, regardless on-going political concerns, Libya still can be significant potential net gas exporter to Europe. It seems that demand for Libyan oil and natural gas is unbendable in spite of security and political instability in the MENA countries.

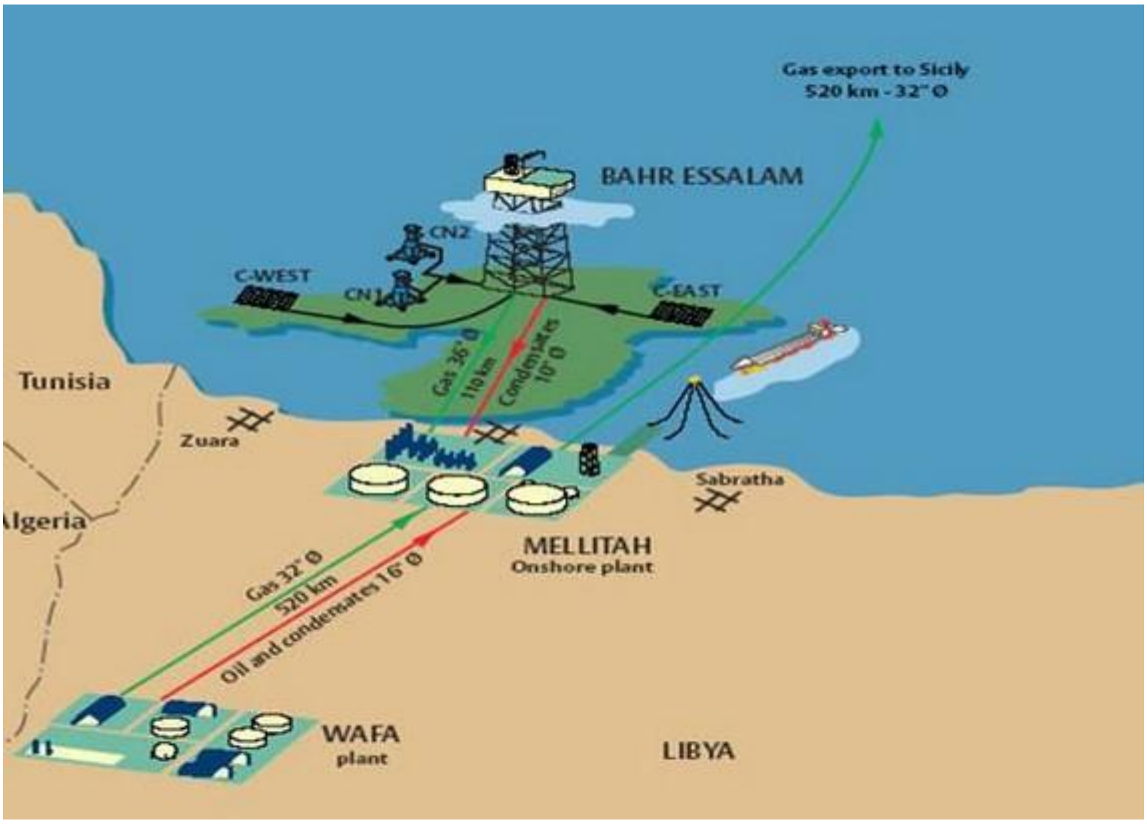

Figure 4.8 Bahr Essalam Field.
Source: ENI, https://www.eni.com/

4.7.3 Environmental Issues

Considering the environmental concerns, natural gas has less CO_2 emissions than other energy sources such as gasoline and coal. Due to environmental legislation and associated policies, natural gas is predicted to continue to be desired as energy source, and the estimated European demand for natural gas is going to increase in future up to 646 bcm in 2020 (Dilaver et al 2013). Natural gas is considered as the best possible partner for renewables in the transition to a low carbon future and gas-fired power plants are more efficient and produce about half the CO_2 emissions of coal-fired power stations.

In this regard both National Oil Cooperation (NOC) and Eni made attempts to use the most advanced technology to develop the recovery of CO_2 injection and water alternate gas. Having joining the Global Gas Flaring Reduction (GGFR) initiative, within the World Bank, Eni has made efforts to reduce gas flaring. According to Eni even though with the political uprising circumstances in countries such as Nigeria and Libya, the company was able to achieve a 75 per cent in reduction in recent years compared to 2007, over the period of 2014 and 2016, and achieved a further 8.8 per cent reduction, aiming in future to achieve a zero process flaring 5 years earlier than scheduled in the agreement (Eni 2016).

Chapter 5

METHODOLOGY

This chapter is divided into three sections: section one is about testing the convergence in CO_2 emissions in EU countries. Section two refers to testing the Environmental Kuznets Curve (EKC) relationships in the Italian economy. Finally section three includes an evaluation for the natural gas pipeline in Libya. The main idea is to inspect first the tendency in the demand in European Union countries for cleaner energy source. Second, the (EKC) relationship in Italy specifically due to the fact that Italy is the number one destination for Libyan natural gas exports and finally evaluation of the natural gas pipeline in Libya.

In order to obtain environmental sustainability, CO_2 emissions convergence has been one of the main subjects for researchers and policy makers and testing CO_2 emissions convergence became very important before choosing the proper environmental policy. In this study we examine the convergence of CO_2 emissions in European Union countries over the period 1980 to 2014. In doing so, two approaches, namely, cross-section and time-series approach are employed. Our findings confirm convergence among CO_2 per capita emissions in European Union countries. This would imply that CO_2 emissions would decline over time, and more usage of lower emissions fuels will be in future, and hence more demand for more efficient energy sources that can help reduce greenhouse gas emissions.

Another special interest in this study is the idea of linking the CO_2 emissions convergence in European Union countries with natural gas market, that is if these countries managed to reduce pollution and seek to use a fossil fuel with lower emissions. Thus, one can conclude higher demand would be on natural gas as a substitute to gasoline. Accordingly, this fact is crucial for countries exporting alternative fossil fuels.

5.1 Convergence Tests for CO_2 Emissions in EU Countries

5.1.1 Data

This study uses the data of the annual emissions of CO_2 in metric tons per capita. The balanced panel consists of annual data for members of European Union countries, namely, Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Spain, Sweden and United Kingdom for the period of 1980-2014[40]. The data are gathered and verified from sources: International Financial Statistics by IMF, European Statistics (Eurostat), World Bank and World Development Indicators[41].

5.1.2 Cross-sectional approach

The model used in this approach is mainly the model used by Strazicich and List (2003). As it was mentioned before, this approach is commonly used in the literature of testing for convergence. In such models, the average annual growth rate of the chosen indicator is regressed on the initial level of itself. Here, in our study, the average annual rate of growth in per capita CO_2 emissions is regressed on the initial

[40] Data of CO_2 per capita for some countries are not available for the same period of time. ie; Croatia, Estonia, Lativia, Lithuania and Slovenia, so they are excluded from our estimated model.
[41] Temperature data are from national Metrological Agencies.

level of per capita emissions. In addition, some control variables such as GDP, Gasoline price, tempreture and pobulation are also included. The model is:

$$1/(T-1) \quad lnCO2pc_{it} - lnCO2pc_{it-1} = \gamma 1 + \gamma 2\, lnCO2pci1980 + \Gamma \ln Z + ui \qquad 4.1$$

Where the variables are:

$1/(T-1) \quad lnCO2pc_{it} - lnCO2pc_{it-1}$; the average annual rate of growth in per capita CO_2 emissions for country i in year t

$CO2pci1980$; the initial value of per capita emissions in country i in 1980

T ; the number of the years in the sample

Z_i ; the vector of all other control variables representing the conditional convergence variables, which may affect the long run emissions rates, these variables are:

GDP; Per capita real GDP, where GDP values are adjusted for purchasing power parity data.

POP; Population: Our model is different from the original one which used population density for the largest city. Here in this study, due to the availability of data for all countries, total population of the whole country is used. Also, 1997 is used as the midpoint year for the crossed-data in our model.

GASP; Energy gasoline prices: This is the price per liter.

ATEM; Average winter temperature: Average January temperature.

As for parameter coefficients; γ_1 is the constant term, γ_2 is the convergence coefficient of the initial value of per capita emissions, $\mathrm{CO2pci1980}$, in country $\boldsymbol{i}$. According to theory γ_2 is expected to be less than zero indicating that countries which start with high per capita emissions would have a lower growth in their emissions than countries with lower emissions at the beginning, and hence they converge. $\boldsymbol{\Gamma}$ is the coefficient vector of control variables Zi as used in work of IPS

(2003). Coefficient of per capita real GDP is expected to have positive sign that is rapid growth in GDP would lead to more CO_2 emissions and negative for the coefficient of Real GDP squared, in order to have an inverted-U-shaped EKC relationship. The coefficient of gasoline price is expected to be negative, that is, if gasoline price increases quantity demanded of gasoline will decrease resulting in lower levels of CO_2 emissions. For the population variable it is predicted in the literature that the more is the population in a country the greater is the awareness about the importance of reducing CO_2 emissions (Strazichich & List 2003). Therefore the coefficient of population is expected to have a negative sign. However, one may argue that higher population leads to more use of energy sources and so more per capita CO_2 emissions. The impact of temperature is also not clear. On one hand it can have positive effect ; that is the warmer the weather the lower is the demand for fuel for heating purposes and so, CO_2 emissions would converge to lower rates. On the other hand it can be said that the higher temperature leads to greater usage of fuel due to transportation demand that due to need for people to go out more often, so CO_2 would diverge over time.

5.1.3 Time series approach (Panel-Unit root-test)

In order to investigate the stationarity of the relative per capita CO_2 emissions (y), it is necessary to do a unit root test. For this, propose our study adopted the model used by IPS (2003)[42] , including first differenced lagged term $\Delta y_{i,t-j}$ in case of possibility of serial correlations (IPS, 2003), which is based on Dickey-Fuller procedure as following:

$$\Delta y_{it} = \alpha_i + \beta_i y_{i,t-1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{i,t-j} + \varepsilon_{it} \qquad (4.2)$$

[42] K.S. Im , Pesaran and Shin. Testing for unit roots in heterogeneous panels, Journal of Econometrics 115 (2003), Pp. 53-74

Where:

α is a constant term and β_i to β_{ij} are parameters in the model, i refers to cross-section data for each country $i = 1, . . ., N$, t indicates time and ε_{it} is the error term.

The hypothesis going to be tested here, is:

H_0: $\beta_i = 0$ for all i, against the alternative

H_1: $\beta_i < 0$

The null hypothesis implies that a unit root exists among series and so CO_2 emissions are not stationary, therefore, the impact of shocks will be permanent, hence we can conclude that CO_2 emissions do not converge. Alternatively, if we reject null hypothesis, thus no unit root exist and CO_2 emissions are stationary, so shocks would have only temporary impact, and CO_2 emissions will converge overtime.

In the line with IPS (2003), in our study, separate unit root tests are used for the N cross-section data. Their test is based on the Augmented Dickey-fuller (ADF) statistics averaged across groups. After estimating the ADF regressions for each country individually, the average of the *t*-statistics for p_1 is computed from the individual ADF regressions, $t_{iT_i}(p_i)$ and then modified in the form of *t*-bar as follows:

$$\bar{t}_{NT} = \frac{1}{N}\sum_{i=1}^{N} t_{iT}(p_i \beta_i) \qquad (4.3)$$

The *t*-bar is then standardized[43] and it is shown that the standardized *t-bar* statistic converges to the standard normal distribution as N and $T \rightarrow \infty$. According to IPS (2003) *t-bar* test is preferred once N and T are small.

[43] Following IPS that derives the asymptotic properties of their panel test static converges to a standard normal distribution which contrasts to univariate ADF tests (Strazicich and List, 2003).

5.2 Tests for Environmental Kuznets Curve (EKC)

Although Italy started NES to achieve targets of EU-2020, 2030 and 2050, Italy's policy still seems not quite clear towards cutting down CO_2 emissions. It is stated that it might be a challenging task for Italy to meet the requirements of Europe environmental strategy for 2020 (Annicchiarico B.2014). For this purpose, in the second part of our study we examined convergence of per capita CO_2 emissions and Environmental Kuznets Curve (EKC). We test this relationship between per capita CO_2 emissions and EKC in Italy for the period between 1970 and 2014.

Therefore, there is need to try to clarify EKC relationships in Italy. So in order to examine the existence of EKC relationship between economic growth and CO_2 emissions in Italy, it is important to involve other significant variables which explain behavior of CO_2 emissions in Italy during the period of the study. These variables are globalization and energy consumption in addition to economic growth.

The other important subject in this section is to examine how far the economy of Italy has gone in achieving cleaner and sustainable environment targeted by the European Environment Agency in order to move forwards environmental sustainability in the European Union countries. Therefore, we also included energy consumption, and globalization similar to works done by Shahbaz et al (2010, 2013) for some other single European countries.

In this part of our study we examine the role of globalization, energy consumption and real income in the attainment of environmental sustainability targets of Italy. To achieve our research objectives, we employ the autoregressive distributed lag model for empirical estimators and Toda and Yamamoto (1995) causality method for predictive analysis using annual frequency data over the periods 1970-2014.

The causal relationship between greenhouse gases (GHG) emissions, globalization, energy consumption and economic growth, globally, has been at the center of attention in the research field regarding improving environmental quality. According to environmental Kuznets (EKC); the environmental consequences of economic growth, globalization and energy consumption may damage the environment in the short run by increasing CO_2 emissions whereas the same variables improve environmental quality by lowering CO_2 emissions in the long run (Shahbaz et al., 2017).

The sources of our data are Real Gross Domestic Product RGDP (unit of measurement 2010 US$ Constant) from World Bank Indicators database (WDI), Energy Usage/Consumption (EC) Oil equivalent/capita (Kg) from (WDI), Carbon dioxide emissions CO_2 (Global hectare of land) from (WDI), and Globalization (GLO) (EC (Economic index) + SO (Social index) + Political Index) from Dreher (2006)[44].

The empirical form of our model is constructed as follows:

$$CO_2 = f\,(EC, RGDP, GLOB) \qquad (4.4)$$

All the variables are transformed into natural logarithm so we write Eq. (4.5) in natural logarithm as shown below:

$$\ln CO_2 = \alpha_0 + \alpha_1 \ln EC + \alpha_2 \ln RGDP + \alpha_3 \ln GLOB + e_t \qquad (4.5)$$

[44] The globalization index has been recently improved by Dreher, Gaston and Martens (2008) and Gygli, Haelg and Sturn (2018). KOF Globalisation Index, introduced and updated in Dreher et al. (2006) & (2008), measures globalization (the economic, social and political dimension). Gygli et al (2019). https://doi.org/10.1007/s11558-019-09344-2.

Where $lnCo_{2t}$ is the natural log of CO_2 emissions per capita, natural log energy consumption, ln RGDP is the natural log of real GDP per capita and ln GLOBt is for natural log of globalization. And, $\alpha_1, \alpha_2, \alpha_3$ are the slope parameters and e_t is the error term.

So, our model suggests that CO_2 emissions (CO_2) in Italy depend on energy consumption (EC), RGDP and globalization (GLOB). And if all things being equal (ceteris paribus) it is expected that, decrease (increase) in ln EC , ln GLOB and ln RGDP would lead to decrease (increase) in CO_2 emissions level (environmental pollution).

We employ the autoregressive distributed lag (ARDL) method which is amenable for short time series data, and providing an empirical evidence of the EKC for the emissions-growth by augmenting the standard GDP variable by globalization, economic growth, and energy consumption (Stern et al., 1996) (Shahbaz et al 2015 & 2017). ARDL is amenable for short time series data as in this study and used here to provide an empirical evidence of the EKC for the emissions-growth by augmenting the standard GDP variable by globalization, economic growth, and energy consumption (Stern et al., 1996) (Shahbaz et al 2015 & 2017). We choose to employ the ARDL model for certain reasons: in addition to the fact that It has popularity for the determination of short-run and long-run relationships between a given set of variables. And Produce objective and precise quantitative results, there are advantages we are concerned about in our research. The ARDL model has better performance, and *t*he ARDL model is able to analyse the long run relationship amongst variables integrated of different order. Also, it is applicable for both non-stationary time series as well as for times series with mixed order of integration.

The unrestricted error correction form of the ARDL model is specified as below:

$$\Delta \ln CO_{2t} = \alpha_0 + \alpha_1\, lnCO2_{t-1} + \alpha_2\, lnEC_{t-1} + \alpha_3 lnRGDP_{t-1} + \alpha_4\, lnGLOB_{t-1} + \sum^{p} \alpha_1 \Delta lnCO2_{t-1} + \sum^{q} \alpha_5\, \Delta lnEC_{\mathrm{t-1}} + \sum^{q} \alpha_6 \Delta lnRGDP_{\mathrm{t-1}} + \sum^{q} \alpha_7 \Delta lnGLOB_{t-1} + \mathrm{ECM}_{\mathrm{t-1}} + \mathrm{e_t} \quad (4.6)$$

5.3 Natural Gas exports from Libya to Italy: Evaluation for the Natural gas Pipeline-New Developments

5.3.1 The Cost Benefit Analysis (CBA)

The other analysis conducted in this study is the evaluation of the existing natural gas pipeline of Libya. For this, cost and benefit analysis (CBA) is adopted using Discount Cash Flow (DCF) technique.

In discount cash flow (DCF) method, capital expenditures (CapEx) include all project's equipment costs, labour cost, development costs and environmental costs relevant to the project under consideration. The operating cost required for the operation and maintenance (O&M) for over the life time of the proposed pipeline project is also included in computations, which covers all fixed and variable costs. On the revenue side of DCF, we include all cash inflows expected from project sales during the life time of the project. The main objective of cost-benefit analysis for investment decisions to make an appropriate evaluation for any project is to create a solid ground to prevent good projects from being rejected and to stop bad projects (Jenkins et al 2011). The choice of the discount rate is usually is a debatable issue because the discount rate is a vital key to decide whether NPV of a project is positive or negative (Jenkins G. and Kuo. 2007).

In our study for all calculations, primarily inflation rate variable has been used instead of interest rates, due to the fact that it reflects the country risk of undertaking projects in Libya. One of the other reasons of using inflation rate is that interest rate is insignificant in Libyan economy[45]. Therefore inflation rate is the most commonly used variable to reflect the opportunity cost in many similar economic studies. All capital costs are incurred in year zero[46] and the revenue from gas sales begins in year 1. The CF_i stands for net cash flows in year n and Net cash flows is calculated as:

Net cash flows = TR_i (revenue in year i) - C_i (costs in year i).

Then discounted to obtain Net Present Value (NPV) for the project under consideration.

$$NPV = \sum_{i=0}^{n} \frac{CFi}{(1+d)^{n}} \qquad (4.7)$$

Where; CF cash flow (cash flow in – cash flow out)

d is the discount rate (WACC)[47].

n time period for the project life time.

Weighted average cost of capital (WACC) is used as calculated in similar studies for similar projects by MIT (2013) and Mac Donald (2010).

The annual expected project revenues from natural gas exports:

$$TRi = \sum_{i}^{n} P.Qi \qquad (4.8)$$

TR, the total annual revenues of natural gas exports,

P is the gas price (U$/mmbtu) which is held constant over time

Qi quantity of natural gas exported via Green Stream Pipeline from Libya to Italy

---

45 This is because of rigidity in the interest rate and more importantly because of Islamic principles that forbidden dealing with interest "Reba", therefore, interest rate cannot represent opportunity cost.

46 In the DCF analysis, it is assumed that the capital is spent in year 0

47 Weighted average cost of capital as used in similar studies for similar projects by MIT, Mac Donald (2010), the formula explained in details in the Appendix.

The total costs include construction costs and O&M of the existing pipeline and Bahr Essalam phase 2 development which was known as 41C.

In addition due to the uncertainty that is commonly associated with the estimation of economic values over a long time horizon, a sensitivity analysis should be performed on the DCF analysis results.

Our predictable outcomes of the pipeline are expected to be sensitive to assumed parameters; exchange rate, inflation rate and gas price which will vary over 20 years. To overcome this problem sensitivity analysis is carried out for those most sensitive variables that we expect to be critical parameters affecting the performance of the proposed project. The next chapter shows the results based on the analysis mentioned above.

Chapter 6

RESULTS

As mentioned before our study is concerned about examining the convergence of CO_2 emissions in EU countries, environmental issues in Italy and evaluating the natural gas pipelines in Libya to export natural gas to Europe. Therefore in this chapter we represent the results of our empirical work in three parts. First, results of testing the convergence of CO_2 emissions in EU countries, then the findings of investigating the role of energy, real income and globalization in the quest to achieve environmental sustainability and testing the EKC in the Italian economy and finally evaluating natural gas pipeline in Libya**.**

6.1 The CO_2 emissions in EU countries

The environmental issues globally are continuously gaining a great consideration. Therefore CO_2 emissions have received considerable attention regarding reduction of polluting gases. In this study the convergence in CO_2 emissions was examined by three approaches among European Union countries during 1970-2014. In doing so, the study performed a cross sectional data approach, ARDL-ECM and IPS panel unit root test are used to investigate the convergence in the relative average of CO_2 emissions. Empirical results of all approaches applied in this study support the existence of convergence.

We start with testing for normality and stationarity of our variables before conducting out esmations as follows:

From normality test results shown in Table 6. 1 and according to the Jarque-Bera (JB) statistic results, we could not reject the null hypothesis and the series are normally distributed. Table 6.1 shows the summary statistics which includes; the mean, median, max, min, standard deviation, skewness, Kurtosis and Jarque-Bera (JB) test statistic which are specified under the null hypothesis of normal distribution. The null hypothesis test states that the population is normally distributed, against the alternative hypothesis that it is not normally-distributed. In other words if the data comes from a normal distribution the null hypothesis for the Jarque-Bera test, that the population which the sample are drawn from has zero skew and zero excess kurtosis, is true. According to the JB statistic results, we could not reject the null hypothesis and the series are normally distributed.

Table 6.1 : Summary statistics

	$LCO_2$1980	LGASP	LGDP	LPOP
Mean	0.913656	1.783333	4.253130	6.995737
Median	0.936251	1.800000	4.344228	7.007801
Maximum	1.481164	2.150000	4.633765	7.913998
Minimum	0.441399	1.420000	3.732780	5.574304
Std. Dev.	0.226675	0.209841	0.225676	0.665680
Skewness	0.080793	0.005698	-1.058315	-0.712840
Kurtosis	3.810641	2.027189	3.569575	2.919803
Jarque-Bera	0.597842	0.828180	4.203970	1.784123
Probability	0.741618	0.660942	0.122214	0.409810
Sum	19.18679	37.45000	89.31574	146.9105
Sum Sq. Dev.	1.027627	0.880667	1.018590	8.862600

Observations	21	21	21	21

In order to test for stationarity in our data by using 3 methods as shown in Table 2 where the unit root test results reveal that our variables are stationary and there was no unit root. The P-value in all 3 tests was less than (0.05) so we reject the null hypothesis that H_0: there is unit root. So, we conclude that the series are stationary.

Table 6.2 : Stationarity test

Method	Statistic	Prob.**
Levin, Lin & Chu t*	-6.69745	0.0000
Im, Pesaran and Shin W-stat	-7.96435	0.0000
ADF - Fisher Chi-square	76.2612	0.0000
PP - Fisher Chi-square	227.739	0.0000

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality. Null: Unit root (assumes common unit root process)

As reported in the following sections all empirical results showed a clear evidence of convergence in CO_2 emissions. Results are summarized here in Table 6.3 to Table 6.8 for cross sectional approach, and and the Autoregressive-Distributed Lags model (ARDL), Error Correction Modeling (ECM) ECM to test the relationships in equation (1) as well and panel unit root approach.

6.1.1 Results of cross sectional approach

The first method presented in Table 6. 3 shows the cross sectional convergence test for CO_2 emissions represented in the coefficient of initial level of CO_2, also the EKC relationship represented with other control variables affecting the environment. The cross sectional regression results are given in Table 6. 3 and as can be seen from the table, the results show that the convergence coefficient is less than zero and statistically significant. This indicates that, there is significant convergence in the CO_2 emissions with respect to 1980 as the initial year. This means the per capita CO_2 emissions among European Union countries has the right expected negative sign and CO_2 emissions are falling over time. As for conditional variables, results show that the per capita GDP is significant in however the inverted U-shaped environment curve does not exist. Results for gasoline price is statistically insignificant, also has the opposite of the excepted sign. Population regressor was significant and with the predicted negative sign. Temperature which represents here the demand for energy use depending on the weather has limited importance, due to the small coefficient size, also was not significant. However, according to some studies the positive sign of temperature suggests that the warmer the weather the more is the demand of using transportations (T. Jobert et al, 2010) and (Strazicich et al, 2003) and so the higher growth in CO_2 emissions.

Table 6.3: Cross-sectional tests for conditional convergence in the average annual rate of growth in per capita CO_2 emissions among European Union's countries (N=21)

Dependent Variable: Average growth rate in per capita CO_2 emissions

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ln $CO_2$1980	-0.018	0.003	-6.2187**	(0.000)
lnGDP	0.007	0.001	4.8361**	(0.000)
lnPOP	-0.002	0.001	-2.7284*	(0.015)
GASP(1)	0.008	0.011	0.6847	(0.503)

ATEM(1)	6.6E-05	0.000	0.5151	(0.614)

R-squared	0.82
Durbin-Watson stat	2.54

Note: * and ** denote significant at 5% and 1% levels respectively

6.1.2 ARDL-ECM estimation

The unrestricted error correction of the ARDL model for this study was carried out for short run and long run relationships for the model represented in Equ. 1, Table 6.4 shows the short and long run coefficients obtained from the ARDL model estimations. Results reveal that CO_2 emissions are converging overtime and supporting the results from the above different approaches at ($P < 0.01$) significance level. The coefficient of real GDP was significant and positive sign, so the economic growth in these countries has negative impact on environment quality at ($P < 0.05$) significance level. In addition the results indicate to the significant of population coefficient with negative sign referring that public awareness in short run would help in reducing environment degradation at ($P < 0.05$) significance level. However, temperature and gas price both were not significant in both short and long run. Results also, show that the adjustment coefficient (CointEq(-1)) the short term speed adjustment of the growth level in CO_2 to its long term steady state path following a shock was negative and significant at ($P < 0.01$) significance level, indicating that deviation from the long term track of CO_2 emissions is completely and will adjusted yearly.

Table 6.4: ARDL-ECM estimation results
Short Run Coefficients

Variable	Coefficient	t-Statistic	Prob.*

LCO21980	-0.0197**	-4.741	0.0004
LGDP	0.008**	3.881	0.0019
LPOP	-0.00178**	-2.323	0.0370
GASP	-0.010780	-0.775	0.4522
ATEM	-0.000101	-0.516	0.6148

Long Run Coefficients

Variable	Coefficient	t-Statistic	Prob.
LCO21980	-0.0178*	-3.974	0.001
LGDP	0.0073**	3.169	0.007
LPOP	-0.0016*	-2.157	0.050
GASP	-0.009713	-0.737	0.474
ATEM	-0.000091	-0.525	0.607
CointEq(-1)	-1.109*	-7.515483	0.0000

Cointeq = AGROWTHCO2 - (-0.0178*LCO21980 + 0.0073*LGDP - 0.0016*LPOP -0.0097*GASP -0.0001*ATEM)

R-squared 0.83
Adjusted R-squared 0.77
Significant at ** , *0.05 and 0.10 level respectivel y

Results reported in Table 6.5 show evidence of existence of long run relationship among our model variables. After conducting cointegration test that show statistic of trace confirms that there is at three cointegrating equations at the 0.05 level of significance. Also, the max-eigenvalue test indicates two cointegrating equations at the 0.05 level of significance. Thus we conclude that the variables follow a stable and long run equilibrium path.

Table 6.5 : Cointegration results
Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.972600	158.8739	83.93712	0.0000
At most 1 *	0.917676	90.52690	60.06141	0.0000
At most 2 *	0.683429	43.08215	40.17493	0.0248
At most 3	0.527233	21.22820	24.27596	0.1155
At most 4	0.303252	6.994289	12.32090	0.3257
At most 5	0.006765	0.128978	4.129906	0.7672

Trace test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.978675	73.10967	40.07757	0.0000
At most 1 *	0.922228	48.52539	33.87687	0.0005
At most 2	0.688347	22.15146	27.58434	0.2127
At most 3	0.539918	14.75065	21.13162	0.3067
At most 4	0.529666	14.33193	14.26460	0.0488
At most 5	0.260347	5.729898	3.841466	0.0167

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

As reported in Table 6.6 for the diagnostic test, the results reveal that there no evidence of heteroscadasticity or serial correlation and the model is normally distributed therefore we can conclude that our model is reliable, robust and adequate for policy formulation.

Table 6.6: Diagnostic test

Test Type	Coeffiecient	P-Value
Heterogenity test (BP-Godfrey)	2.465	0.087
Normality test (JB)	0.982	0.612
Serial Correlation test (BG)	0.457	0.645

Breusch-Pagan-Godfrey
JB: Jarque-Bera-Test
BG: Breusch-Godfrey-LM Test

The empirical results of our work showed a strong evidence of convergence in CO_2 emissions among European Union countries, meaning that carbon emissions will continue to decrease overtime, thus improving the environmental quality. In addition, for the economic growth our results follow the theory that the economic growth is causing environmental degradation, also we found that energy price is not significant in determining carbon emissions behaviour, the same can be concluded regarding energy seasonal demand represented in temperature coefficient. On the other hand public awareness is statically significant and important towards achieving clean environment goals.

6.1.3 Results of Time series approach: Panel unit root test

Panel unit root test results came together with cross sectional results. As shown in table 6.7 results are both consistent revealing a conclusion of existence of convergence. Results suggested that CO_2 are stationary and there was no unit root among per capita emissions and they have converged over time.

Table 6.7: Panel Unit Root Test- Im, Pesaran and Shin (IPS)

Method : Im, Pesaran and Shin W-stat	Level		First order difference	
	Constant	Constant + Trend	Constant	Constant + Trend
Statistic	-0.82362	1.14243	-12.0508*	-9.73344*
Probability	(0.2051)	(0.8734)	(0.000)	(0.000)

* indicates rejection of the null hypothesis of unit root at 1% and 5%, levels of significance.Total (balanced) observations: 672, Cross-sections included: 21, Probabilities are computed assuming asymptotic normality

Table 6.7, presents the results of the IPS panel unit root test before and after taking the first deference's of log of CO_2 for 21 countries[48]. The sign is negative as it was expected according to theoretical background of this test as mentioned previously. Where the dependent variable is the natural logarithm of the ratio of annual per capita CO_2 emissions for country i in year t divided by the average per capita CO_2.

[48] The Im, Pesaran, and Shin, and the Fisher-ADF tests all allow for individual unit root processes so that may vary across cross-sections. The tests are all characterized by the combining of individual unit root tests to derive a panel-specific result.

These results clearly show that the null hypothesis of a panel unit root in the average per capita CO_2 can be rejected.

Results indicate that the per capita CO_2 emissions data are stationary. Also, we test for stationarity there is no time trend, then allowing for a constant plus time trend. Several tests have been done; in the absence and with existence of a constant plus time trend and without. The Fisher-type unit root test probabilities are estimated using asymptotic chi-square distribution, so we tested stationarity for each of the variables in our model. The results reported in Table 6.7 show that the null hypothesis of the presence of unit root cannot be rejected at level for all the variables. This implies that each time series is non-stationary at level. However when we tested each for unit root at first difference the null hypothesis for all the series are rejected and they are stationary at first difference.

Therefore, as can be concluded from the results of IPS panel unit root that the null hypothesis of unit root is, strongly, rejected in all countries, after taken first differences. All tests statistics in both with and without trends, significantly, confirm that in all European Union's per capita CO_2 emissions are stationary. Also, our results confirm the presence of convergence in CO_2 emissions in EU countries therefore resonate with the findings of Jobert et al (2010). Also, from our results in Table 6.8, given the probability value of Breusch-Pagan-Godfrey statistic we could not reject the null hypothesis of heteroskedasticity in our data, so we can conclude that our variables are free from heterogeneity.

Table 6.8: Heteroskedasticity Test

F-statistic	0.538752	Prob. F(5,14)	0.7440

Obs*R-squared	3.227266	Prob. Chi-Square(5)	0.6650
Scaled explained SS	0.709754	Prob. Chi-Square(5)	0.9824

Breusch-Pagan-Godfrey

Accordingly, our findings from all the three previous approachs suggest that CO_2 emissions of European Union countries would decline over time, therefore, one can conclude that more usage of lower emissions fuels would be in future. This conclusion leads policy makers to using more secure and sustainable energy source as natural gas to meet environmental goals. Therefore, the study outcomes would shed a light in testing environmental policies in European Union countries.

6.2 Results of EKC test- Italy

This section focuses on estimation of EKC for Italy. Also, we examine the effect of globalization, energy consumption and economic growth on environment in Italy reflected in CO_2 emissions per capita, to evaluate the Italian consumption trend in terms of efficient energy sources, as indication for Italy commitment towards reducing CO_2 emissions and implementing energy conservation-environmental sustainability policies to reduce environmental pollution and therefore meeting the environmental standard in the context of European framework. To examine the validity of a long-run relationship in our study there are different methods used which are normally related to Johansen's Cointegration Technique (Johansen 1991), ECM, Granger causality (Engle & Granger 1987) and (ARDL) (Pesaran & Shin 1998, Pesaran et al. 2001).

Normality is an important assumption for the regression analysis. Accordingly, we tested our model for normality of our variables. Normality test is widely used in statistical analysis where the variables are distributed approximately normally, so, it is easy to work with and due to its mathematical properties it is more popular and easy to calculate[49]. so many kinds of statistical tests can be derived for normal distributions. In fact, almost all statistical tests assume normal distributions, hence if the mean and standard deviation of a normal distribution are known, tests work well.

Table 6.9: Summary statistics

	LCO_2	LEC	LGLOB	LRGDP
Mean	1.937268	7.849583	4.279167	10.27575
Median	1.928619	7.855340	4.264810	10.35112
Maximum	2.106143	8.075481	4.407442	10.55155
Minimum	1.662195	7.575148	4.140669	9.778662
Std. Dev.	0.110461	0.143420	0.098524	0.234860
Skewness	-0.388003	-0.023485	-0.011248	-0.671347
Kurtosis	2.577129	1.782431	1.374420	2.177276
Jarque-Bera	1.464383	2.783776	4.955656	4.649441
Probability	0.480854	0.248606	0.083925	0.097811
Sum	87.17707	353.2313	192.5625	462.4086
Sum Sq. Dev.	0.536867	0.905055	0.427108	2.427015
Observations	45	45	45	45

Table 6.9 shows the summary statistics which tests the normal distribution for the population. The Jarque-Bera (JB) statistic results, refer to the observed data are

[49] The whole theory of sample tests t, f and chi-square test is based on the normal distribution.

consistent with the assumption that the null hypothesis is true, so we could not reject the null hypothesis, this indicate that the series are normally distributed.

Also, we checked the correlation among our variables as shown in table 6.10.

Table 6.10: Correlation test results

Correlation	LCO2	LEC	LGLOB	LRGDP
LCO2	1.000.000			
t-Statistic	-----			
Probability	-----			
LEC	0.809323***	1.000.000		
t-Statistic	9.035.445	-----		
Probability	0.0000	-----		
LGLOB	0.510066***	0.903379***	1.000.000	
t-Statistic	3.888.605	1.381.358	-----	
Probability	0.0003	0.0000	-----	
LRGDP	0.667255***	0.939570***	0.936014***	1.000.000
t-Statistic	5.874.482	1.799.637	1.743.889	-----
Probability	0.0000	0.0000	0.0000	-----

*** Correlation coefficient is significant at 1 %

According to our results presented in Table 6.10, we found strong estimated correlation coefficients among CO_2 emissions, real income, energy consumption and globalization respectively. Results show a significant, strong and positive estimated correlation coefficients between CO_2 emissions and energy consumed (0.809), between globalization and CO_2 emissions (0.510), globalization and energy consumption (0.903), real GDP per capita and CO_2 emissiomns (0.667), real GDP per capita and energy consumption (0.939) and between real GDP per capita and globalization (0.936) respectively. This signifies that, the variables are highly linearly correlated and there is functional relationship among the series. Thus, we assume that an increase/decrease in any of these variables will have a significant increase/decrease impact on the others.

Figures 6(1-4) illustrate the graphical plot of the series. The plots show that, energy consumption and CO_2 emissions have been declining overtime. Although, the decrease in CO_2 emisisions seem to be more persistent compared to that of energy consumption and real income. From a policy perspective, it appears that energy conservation policy introduced to reduce environmental pollution by the government is consistent with the country stated macroeconomic objectives in Italy. The increase in the level of globalization (economic, social and political), energy consumption, and real income, carbon emissions level has been declining rate overtime. This is an improvement in energy conservation-environmental sustainability policies for the nation. In addition, these moves, also, substantiate the fact that, Italy has been successful in fighting environmental pollution and also Italy appears to have achieved the year 2020 target set by the EU for all European countries (European Environment Agency, 2018).

Figure 6.1-4: Graphical plots of the natural logarithms of CO_2, EC, RGDP & GLOB.

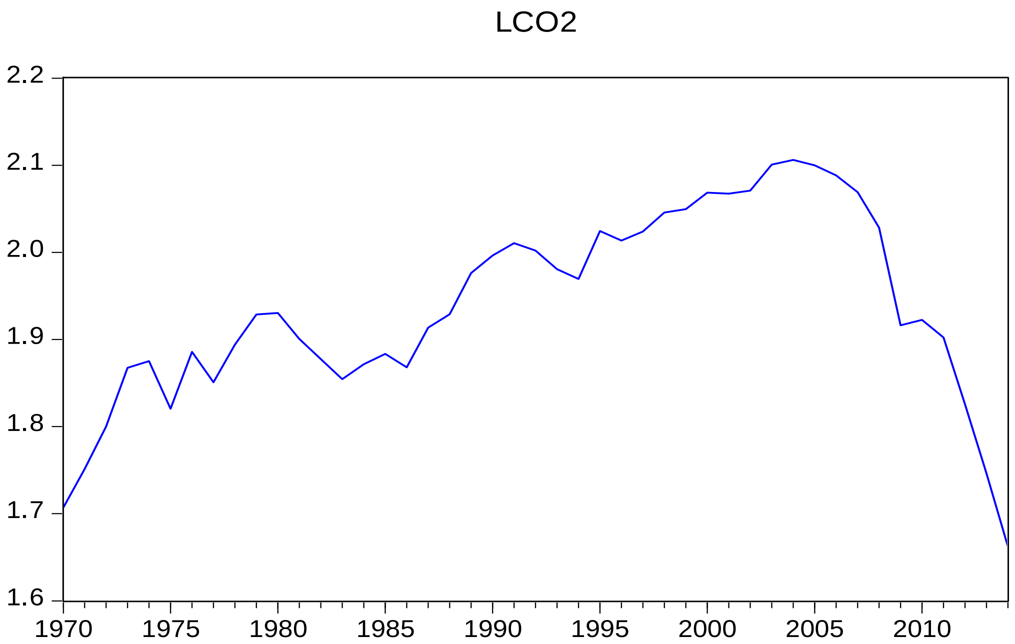

Figure 6.1: L CO_2 emissions

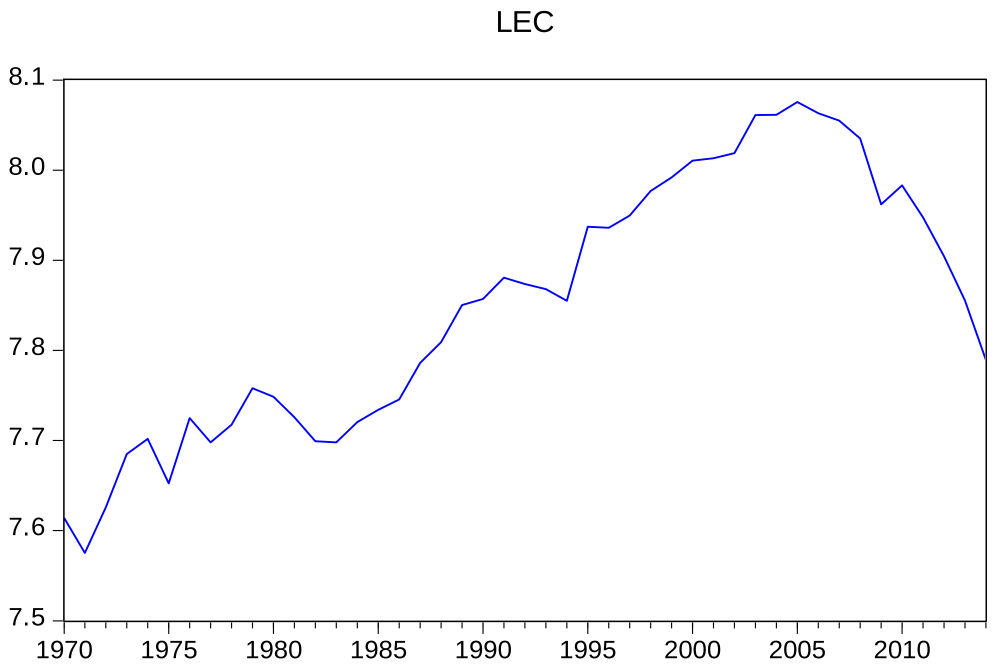

Figure 6.2: L Energy Consumption

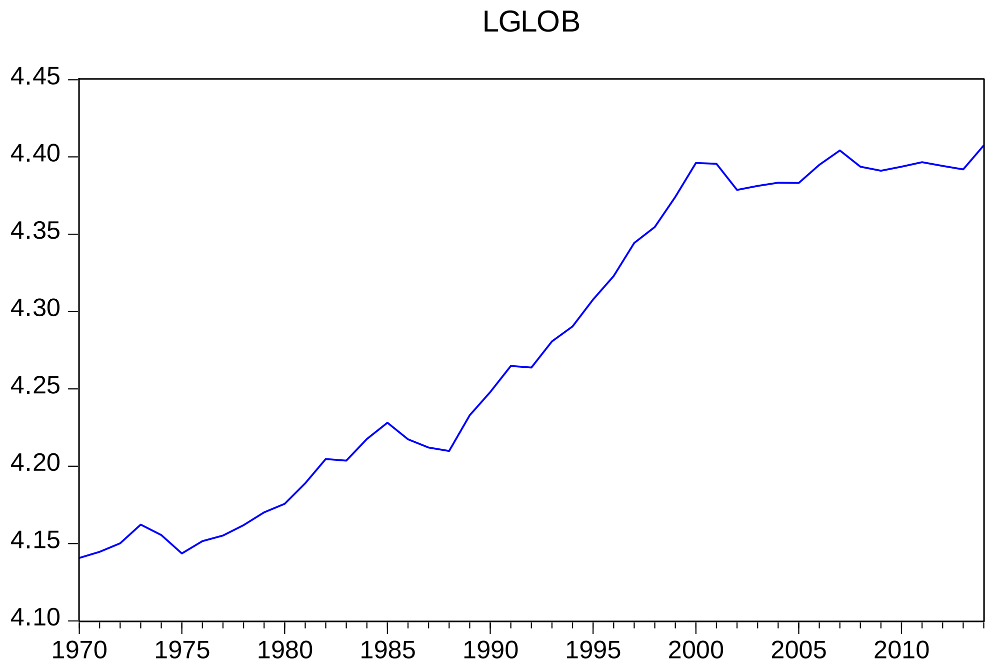

Figure 6.3: L Globalization

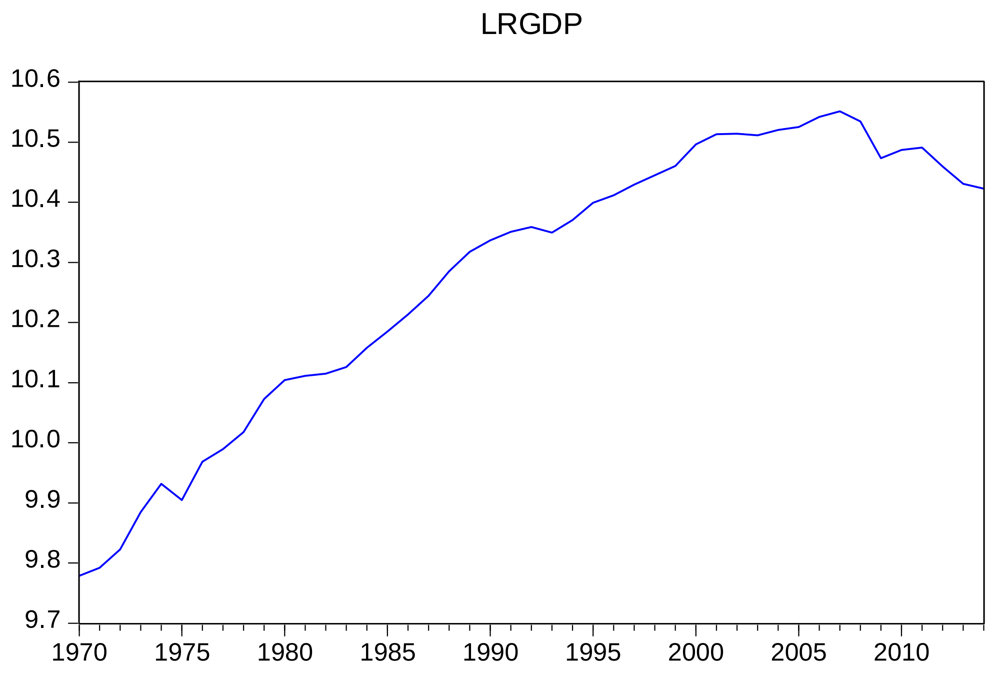

Figure 6.4: LReal GDP

The results obtained from different estimation techniques employed are shown in this section as follows:

In order to conduct a meaningful statistical analysis regardless of the method of choice we need to assess the stationarity of the involved variables[50]. This is important because stationarity or non-stationarity of the under consideration time series may have a strong influence of the series behavior and properties. For example a famous fallacy of the usage of non-stationary data in statistics would lead to having a spurious regression which refers to obtaining a relationship in a regression between two variables despite that they are independent. This kind of regression has a misleading significant coefficient estimates and an unreliable high fitness degree in the model.

Therefore we tested for stationarity of our variables using unit root test. Table 6.6 below shows the unit root results for Augmented Dickey and Fuller (1979) in the first method presented in the first and second row while the second method presents the Zivot and Andrews (2002) unit root results. The Zivot and Andrew approach to unit root testing controlled for endogenous structural break or regime switching in time series. Findings from Table 6.11 shows that the variables are not stationary in their level forms, due to the non-rejection of the null hypothesis of a unit root. However, they all become stationary when the variables were differenced at ($p < 0.01$) significance level. Hence, we conclude that the series are all integrated at order one, i.e., $I(1)$. The regime switching (structural breaks) dates as presented in Table 6.11 for globalization is 1990s and for real income, CO_2 emissions and energy consumption within the 2000s respectively. These dates appears to be of significance to the economy of Italy. Noticeably, it appears the global economic and financial crises experienced between the period 2007–2009 has a rippled effects on the CO2

---

[50] Stationarity refers to the state of a time series with a constant mean, constant variance and constant auto-covariances over time.

emissions, real income or output and energy usage of Italy, as the break dates reported in Table 6.11 fall in between these periods except for globalization index. The break dates as reported for globalization, substantiate the periods the economy of Italy was integrated into global economy.

Table 6.11: Stationarity test results

Method	Form	LCO2	LEC	LRGDP	LGLOB
ADF	Level	−0.804 (0.807)	−1.580 (0.483)	−1.368 (1.000)	−0.546 (0.871)
	Ist Diff.	−5.404(0.000)	−6.618 (0.000)	−4.402 (0.001)	−4.612 (0.003)
ZA	Level	−0.551	−0.609	−1.148	−2.815
	Break	(2007)	(2007)	(2008)	(2001)
ZA	Ist Diff.	−4.041***	−3.327***	−3.271***	−3.268***
	Break	(2007)	(2007)	(2007)	(1993)
I. Order		I(I)	I(I)	I(I)	I(I)

*** at significance level of 1%

Also, we conduct cointegration test. Cointegration[51] which imply that a linear combination of non-stationary variables can be stationary and to have a long-run relationship and so we can avoid spurious regression.

Table 6-12: Cointegration test results

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value	Max-Eigen Statistic	Prob.***
None *	0.422383	48.11001**	47.85613	23.05149*	0.0473
At most 1	0.255363	25.05851	29.79707	12.38407	0.1594
At most 2	0.231033	12.67444	15.49471	11.03372	0.1273
At most 3	0.038312	1.640721	3.841466	1.640721	0.2002

The test indicates at least one cointegrating eqn(s) at the 0.05 level and * the 0.01 level, ***MacKinnon-Haug-Michelis (1999) p-values

[51] In general if a non-stationary series must be differenced d times before becoming stationary the series is said to be integrated of order d and is denoted by I(d) .

The above Table 6.12 supports the long-run relationship among the series via cointegration testing approach that generates the trace and maximum eigenvalue statistics introduced in the work of Johansen (1988, 1991,1995) and improved upon in the study of Reinsel and Ahn (1992). Findings from Table 6. 12 show evidence in support of at least one cointegration equation for trace at ($p < 0.05$) and Max-Eigen at ($p < 0.10$) significance levels respectively. Hence, we conclude that, the variables do follow a stable and long-run equilibrium path[52].

As mentioned earlier, in order to determine the existence of different relationships between Co_2 emissions and other environmental variables we employ the Autoregressive-Distributed Lags model (ARDL).

The results are represented in Table 6.13 and Table 6.9 which report the results of the ARDL model and error correction model (ECM)[53].

Table 6.13: ARDL Cointegrating And Long Run Form-ECM estimation results (long-run)[54]

Dependent Variable: LCO2

Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LEC	1.7966***	0.217689	8.252880	0.0000
LRGDP	-0.0932	0.127060	-0.733622	0.4676
LGLOB	-1.769***	0.280119	-6.315213	0.0000
C	-3.636***	0.432729	-8.402411	0.0000
Adjustment coeff.(-1)	-0.517***	0.105285	-4.909279	0.0000

ARDL estimation results (short-run)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*

[52] We use 1 as optimal lag length to estimate the VAR from the unrestricted vector autoregressive model.

[53] The error correction model (ECM) is a time series regression model that is based on the assumption that two or more time series exhibit an equilibrium relationship that determines both short-run and long-run behavior.

[54] Cointeq = LCO2 - (1.7966*LEC -0.0932*LRGDP -1.7690*LGLOB -3.6360)

LEC	0.9286***	0.133313	6.965524	0.0000
LRGDP	-0.048180	0.062920	-0.765737	0.4484
LGLOB	-0.9144***	0.148114	-6.173329	0.0000
C	-1.8793***	0.431774	-4.352606	0.0001

R^2	0.95	Adjusted R^2	0.945
F-statistic	187.432	prob	0.0000

*** significant and stationary at 1%

The high value R^2=0.95 of the coefficient of determination of the ARDL-ECM model signify that the adjustment coefficient of the specified model is significantly robust in the short-run. And the model joint statistic (F-stat = 187.43, p-value = 0.00), which indicate overall robustness and significance of the series is reported significant at ($p < 0.01$) significance level.

From the speed of adjustment estimated coefficient, we conclude that deviation from the long-term track from the per capita CO_2 emissions is adjusted by 0.516 per cent yearly. By implication, the economy of Italy is converging moderately towards its long-run environmental sustainability. Furthermore, it is interesting to mention that when we tested our model for the inverted U-shaped EKC, our results reveal that this relationship does not exist for Italy for the period of our study, that both coefficients of real GDP and real GDP^2 are statically significants but both have the opposite expected sings (-0.41) and (0.02) respectivly[55].

Results as reported in Table 6.14 row 1 show that globalization index Granger cause CO_2 emissions at ($p < 0.05$) significance level. This finding signifies a one-way predictive relationship from globalization to CO_2 emissions, hence we conclude that, globalization have predictive power over CO_2 emissions. In addition, results (Table

[55] See the Appendix.

6.14 row 3) show that energy consumption Granger cause CO_2 emissions and CO_2 emissions Granger cause energy consumption (Table 6.14 row 4) at ($p < 0.05$) significance level. This finding signifies a two-way predictive relationship between CO_2 emissions and energy consumption. From a policy viewpoint, it appears increase/decrease in energy consumption influences increase/decrease in CO_2 emissions. Furthermore, results (Table 6.14 row 5), also show that real income Granger causes CO_2 emissions at ($p < 0.05$) significance level. This result also signifies a one-way predictive relationship from real income/output to CO_2 emissions, hence we conclude that, real income/output have predictive power over CO_2 emissions. However, we could not reject the null hypothesis of no predictive relationship from CO_2 emissions to globalization (Table 6.14 row 5) and from CO_2 emissions to real income RGDP (Table 6.14 row 6) respectively. This indicates that, CO_2 emissions in this region may not necessarily influence energy consumption and real income output. These results resonate with the findings of (Akadiri, Lasisi, Uzuner & Akadiri, 2018).

Finally, results show that real income or output Granger cause globalization index at ($p < 0.05$) significance level (Table 6.14 row 11). This finding signifies a one-way predictive relationship from real income/output to globalization, hence we conclude that, real income/output predict changes in globalization, as globalization could not predict changes in real income/output (Table 6.14 row 12). Similarly, based on results as reported in Table 6.14 row 7-10, we could not reject the null Hypothesis of no predictive relationship between globalization and energy consumption and between real income/output at all significance levels. This signifies the existence of neutrality hypothesis. From a policy viewpoint, changes in globalization and real GDP may not necessarily influence changes in energy consumption and vice versa.

Table 6.14: Granger causality results

Regressors	MWald	P-Value	Causality
LGLOB → LCO_2 (1)	6.356**	0.041	*Yes*
LCO_2 →LGLO (2)	1.170	0.557	No
LEC → LCO_2 (3)	8.818**	0.012	Yes
LCO_2 → LEC (4)	7.968**	0.018	yes
LRGDP → LCO_2 (5)	7.020**	0.029	Yes
LCO_2→ LRGDP (6)	3.488	0.174	*No*
LGLOB → LEC (7)	1.221	0.542	No
LEC → LGLOB (8)	1.384	0.500	No
LEC → LRGDP (9)	4.030	0.133	No
LRGDP→ LEC (10)	0.204		No
LRGDP → LGLOB (11)	6.392**	0.040	Yes
LGLOB → LRGDP (12)	3.121	0.209	No

Regressors are stationary at *** 0.01 and ** 0.05 level

The empirical results reported in Table 6.14 show that, energy consumption, real income (output) and globalization play a significant role in achieving environmental sustainability in the case of Italy. The impact of these variables in the quest to curb or reduce to minimal greenhouse gas emissions and enforce environmental sustainability both in the short-run and long-run can never be overemphasized. Interestingly, we found that increase in kg oil equivalent per capita of energy consumed country appears to have decreasing impact on CO_2 emissions level. Interestingly, it seems the case, in Italy, that there is reverse relationship, despite the two-ways predictive relationships recorded among energy usage and CO_2 emissions. In Figure 6.2, it was observed that, increase in one unit of per capita of energy consumed leads to more reduction in metric ton per capita of CO_2 emissions. This result shows that energy or environmental conservation policies are in tune with macroeconomic objectives in the case of Italy (Akadiri, Saint Akadiri & Gungor, 2019).

In addition, result show that increase in the level of globalization through trade openness has an inverse impact on environmental pollution in Italy. This indicates that, the government and policymakers of Italy have put in place sound energy and macroeconomic policies. We infer that environmental policies and macroeconomic objectives of Italy are in tune with their energy conversation policy. It will be theoretically right to assume that, as an economy become more open to the rest of the world in terms of trade via importation and exportation of energy products, production would increase, hence a rise in the pollution level. However, it appears government and policymakers of Italy have been able to overturn the tide. We observed that, the more the economy of Italy become open through trade, the less their emissions level, hence increase in environmental quality. This finding is confirmed by the neutrality hypothesis reported between globalization index and metric ton per capita of CO_2 emissions reported in Table 6.14, row 7-8.

Globalization level in Italy has no predictive power over the metric ton per capital of CO_2 emissions generated in the sampled country. Thus, increase/decrease in globalization index may not necessarily influence increase/decrease in environmental pollution (see Shahbaz 408 et al 2018; Alola, 2019).

Furthermore, it has been argued that, the higher the level of economic (production) activities, the higher the CO_2 emissions generated, and vice versa. However, our empirical results show that real income/output has no significant impact on CO_2 emissions in Italy both in the short- and the long-run. This result indicates that, environmental pollution in Italy is not output driven. It appears production activities in the sampled country has moved from high emitted energy sources to low emissions sources such as renewable or natural gas.

Results as reported in Table 6.15 show the diagnostic test. From the results, we found that the specified empirical model is strong, reliable and adequate for policy formulation, since we could not reject the null hypothesis that the model is heteroscedasticity, serial correlation free and normaly distributed.

Table 6.15: Diagnostic Test Results

Diagnostic Test	Coefficient	P-value
Heterogeneity	0.227	0.214
Normality	1.193	0.550
*Autocorrelation	3.121	0.096

* Breusch Pagan autocorrelation test

our empirical discussion will be incomplete without pointing out the significance of the estimated coefficients reported for the constant terms both in the short-run and long-run (Table 6.13). If there is one particular policy implication one can suggest from the negative and statistically significant coefficients of this autonomous term on the metric ton per capita of carbon emissions is that, the economy of Italy is immune to environmental pollution.

From the policy perspective, it appears Italy in an energy-independent economy. Thus, economic growth is not a function of energy consumed and/or produced. By implication, increase in real income would not contribute to increase in metric ton per capita CO_2 emissions, while the introduction of energy conversation policy to maintain and sustain sound and cleaner environment would not by any chance slow down economic performance or hurt the economic growth process of Italy. This finding is confirmed by the neutrality hypothesis reported between real income/output and metric ton per capita of CO_2 emissions reported in Table 6.14, row 9-10.

6.3 Cost-Benefit Analysis Results

This part of our analysis includes cost-benefit Analysis (CBA) to evaluate natural gas Green stream pipeline with the recent developments in Bahr Essalam Field to determine the viability in terms of the technical side, costs and expected revenues of the project.

In such projects, generally, (CBA) is used for evaluating the project under consideration by discounting the cash flow from the project life. It is also used as discounted cash flow (DCF) which is a standard method for appraising a common range of assets such as oil and gas pipelines and other assets like stocks, bonds and real estate investments (Henson, 2017).

In the CBA, the DCF is a direct valuation technique that projecting future cash flows (in/out) of a project and then calculating the Net Present Value (NPV) for those cash flows. NPV is a mathematical technique for interpreting the projected annual cash flow values into today-equivalent values. In this analysis, the cash flows are projected by using a series of assumptions about how it is expected for the project under consideration to perform in the future, and forecasting the generated revenues or income during the project life.

The financial performance of the pipeline is assessed using the Financial Net Present Value (FNPV), and Internal Rate of Return (IRR) indicators. The assumptions are in table 6.16 as following:

Table 6.16: Greenstream-Pipeline Parameters Table[56]

Capacity*	(mmbtu/yr)	1,059,450000.0
Capacity utilization factor		85%
Output**	(mmbtu/yr)	900,532,500.0
Construction Period (Months)	1 year	
Fuel loss factor		8%
O&M cost	($million)	0,31148237
Feed gas cost	($/mmbtu)	2,50
Capital cost	($million)	6600,0
phase ii development costs	($ million)	500
phase ii production	bcm/y	154679700,0
phase ii start date		2018
Gas price	$/mmbtu	5
Inflation rate (Libya)		2,6%
exchange rate (USA$-LYD)		1,36
Tax rate		30,0%
Tax depreciation		3,3%
Cost of Capital (WACC)		8,40%

Capacity (for the proposed level production) is calculated in our study for increasing the production level to 30 bcm/yr. Output level is the (Capacity utilization factor x Capacity utilization factor). Feed gas cost, Tax and WACC are from secondary sources of similar studies regard pipelines (Mac. Doland, 2010)[57]. Pipeline capacity bcm/y: is adopted from (http://www.wiki30.com/wa?s=Greenstream_pipeline). We used gas price of (5$/mmbtu), which is used in IEA projections for gas price in Europe and Asia, as the Europe average border natural gas price between current 4,5 and historical natural gas price 6,6 (Federal Reserve Economic Data).

[56] The source for these parameters/data is in the Appendix.
[57] The civil war in Libya during the period of our study limited our data resources.

The operation and maintenance (O&M) costs are estimated as the 5% of the in such project (Mac. Donald, 2010). Given the current situation in Libya and the political instability, collecting needed information and developing a proper model for such a project was challenging. In the absence of such studies for Libya, we have taken the estimate made by Mac. Donald (2010) for the WACC. The total gas delivered (or output) is equal to gas capacity * capacity utilization factor. The project Revenues from gas sales are calculated from as the gas price ($/mmbtu) * gas output (mmbtu), while the total income (taxable) is a difference of the revenue and expenses. The 'Net' cash flows are a difference of 'Cost' cash flows and the revenue. The proposed capacity of the plant will be 30 (mmbtu/yr), and the capacity utilization factor is assumed 85%. This is in the first scenario without Bahr Essalam phase ii and the second scenario with the developments of Bahr Essalam[58] the proposed capacity is assumed to increase by 12.6 (mmcm/d) at cost of 500 million $.

According to the CBA / DCF analysis to test whether the project, financially, is viable or not; a project is financially desirable if it's financial net present value (FNPV) is greater than zero, and the internal rate of return (IRR) is higher than the discount rate, weighted average capital cost (WACC), in our study. The results, of our CBA study using DCF analysis, are shown in table 6.17 & table 6.18.

Table 6.17: Financial assessment to the Green Stream Pipelines (excluding) Bahr Esalam Phase ii

year	0	1	2	3	4		20
Capital costs ($ million)	6600,0	0	0	0	0	…..	0
O&M Cost ($ m)		310,82	318,90	327,19	335,70	…..	506,18

[58] This is a development for natural gas field is tied back to the Sabratha platform, this field is operated by Mellitah Oil and Gas which is a consortium between National Oil Corporation and ENI-North Africa.

Feed gas Cost ($ million)		2494,66	2559,52	2626,06	2694,34	…..	4062,66
Total Expenses		2805,47	2878,41	2953,25	3030,04		4568,84
Gas price ($/mmbtu)		5,13	5,26	5,40	5,54	…..	8,35
Gross Revenue	0	4619,73	4739,84	4863,08	4989,52	…..	7523,44
Total Cash Outflow (-)	6600	2805,47	2878,41	2953,25	3030,04	…..	4568,84
Total Cash Inflows (+)		4619,73	4739,84	4863,08	4989,52		7523,44
Net cash Flow Before Tax	-6600	1814,26	1861,43	1909,83	1959,48	…..	2954,60
Tax		544,28	558,43	572,95	587,85	…..	886,38
Net cash Flow after Tax		1269,98	1303,00	1336,88	1371,64	…..	2068,22
Discounted Cash Flow	-6600	1141,88	1053,40	971,77	896,46	…..	246,64
NPV ($million-real values) (WACC)@ 8,4% = 8006.18, IRR = 9%							

Table 6.17 shows the FNPV of the expanding the natural gas production without the developments of Bahr Essalam Phase ii (using a discount rate of 8.4%) is equal to US$ 8006.18 m and IRR is 9%.

Table 6.18: Financial assessment to the Green Stream Pipelines (including) Bahr Esalam Phase ii

year	0	1	2	3	4		20
Capital costs ($ million)	6600,0	0	0	0	0	…..	0
Phase ii development cost ($ million)	500	0	0	0	0		0
O&M Cost ($ million)		310,82	318,90	327,19	335,70	…..	506,18
Feed gas Cost ($ million)		2494,66	2559,52	2626,06	2694,34	…..	4062,66
Total Expenses		2805,47	2878,41	2953,25	3030,04	…..	4568,84
Gas price ($/mmbtu)		5,13	5,26	5,40	5,54	…..	8,35
Gross Revenue	0	5413,24	5553,98	5698,39	5846,54	…..	8815,70
Total Cash Outflow (-)	7100,0	2805,47	2878,41	2953,25	3030,04	…..	4568,84
Total Cash Inflows (+)	0	5413,24	5553,98	5698,39	5846,54		8815,70

Net cash Flow Before Tax	(7.100,0)	2607,77	2675,57	2745,13	2816,51	…..	4246,87
Tax	0	782,33	802,67	823,54	844,95	…..	1274,06
Net cash Flow after Tax	(7.100,0)	1825,44	1872,90	1921,59	1971,56	…..	2972,81
Discounted Cash Flow	(7.100,0)	1641,31	1514,12	1396,79	1288,55	…..	354,51
NPV ($million-real values) (WACC)@ 8,4% = 13894,5 and IRR = 15%							

As reported in Table 6.18 the FNPV of the expanding the natural gas production including the developments of Bahr Essalam phase ii (using a discount rate of 8.4%) increased to US$ 13894,5 m and IRR increased to 15%.

Therefore, the financial analysis for both cases shows positive NPV but with the developments in Bahr Essalam phase ii Libya is able to generate higher returns from producing more natural gas.

6.3.1 Sensitivity and Risk Analysis

Due to the uncertainty which is usually associated with the estimation of financial values over a long time horizon, we performed a sensitivity analysis on the CBA results. Here our predictable outcomes of the pipeline are expected to be sensitive to parameters in our assumptions including; exchange rate, inflation rate and gas price, which will vary over 20 years of the analysis results. To overcome this problem sensitivity analysis is carried out for those most sensitive variables that we expect to be critical parameters affecting the performance of the proposed project.

As show on table (6-8) below refer to the sensitivity of the project outcomes with respect to the change in key variables including: Gas price, exchange rate and inflation rate. The present values of gas exports are independent of exchange rate. Our results show that expected NPV of out project is most sensitive to the variation in gas prices and inflation rate, whereas predicted project outcomes is independent from exchange rate.

As shown on Table 6 (19-21) and Figure 6 (5-7) below refer to the sensitivity of results show that the NPV for the green stream pipeline becomes negative only when the gas price is 3$ per mmbtu or less, whereas the NPV is positive at any price otherwise above that, here US$ 5 per mmbtu is used in our study. For exchange rate project's NPV is independent of exchange rates and remain with the same NPV no matter how much the exchange rate was, for inflation rate stays positive at all expected inflation rate.

Table 6.19: Sensitivity analysis of NPV (@ 8,4%) of PV to Gas price (US$/mmbtu)

Gas price (US$/mmbtu)	FNPV (US$ in millions
3	-4281,997871
4	1954,524405
5	8006.1800
6	14427,56896
7	20664,09123

This sensitivity analysis is done to check the impact on the project performance indicators of different gas prices betwee 3 (US$/mmbtu) and 7 (US$/mmbtu). The expected FNPV of out project is sensitive to the variation in gas prices.

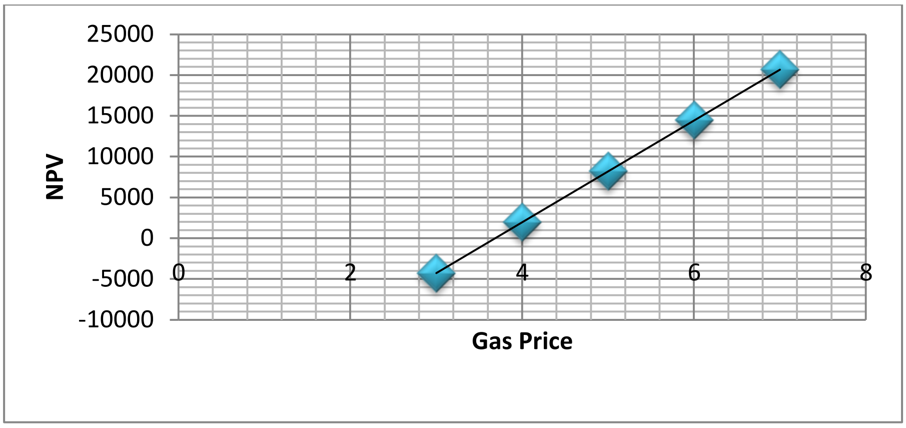

Figure 6. 5: Sensitivity analysis (Gas price)

Table 6.20: Sensitivity analysis of NPV (@ 8,4%)of PV and to exchange rate (LD/US$)

exchange rate (LD/US$)	FNPV (US$ in millions
1,08	8006.1800
1,22	8006.1800
1,36	8006.1800
1,50	8006.1800
1,64	8006.1800

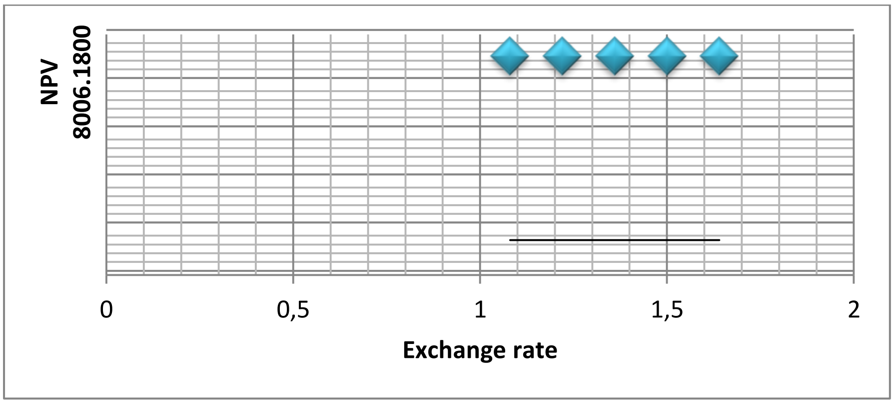

Figure 6.6: Sensitivity analysis (Exchange rate)

The Figure 6.6 shows that the present values of gas exports are independent of exchange rate. This could be due to the fixed exchange regime policy in Libya, and it might be better to use other variables in future study such as centeral bank reserves.

Table 6. 21: Sensitivity analysis of NPV (@ 8, 4%)of PV and to Inflation rate

Inflation rate (Libya)	FNPV (US$ in millions)
1,8%	7197,161
2,2%	7683,210
2,6%	8006.180
3,0%	8721,767
3,4%	9276,524

This part of the sensitivity analysis is to see the impact on the project performance indicators to different inflation rate range between (1.8% & 3.4%). The expected NPV of out project is sensitive to the variation in the inflation rate but never get negative (Figure 6. 7).

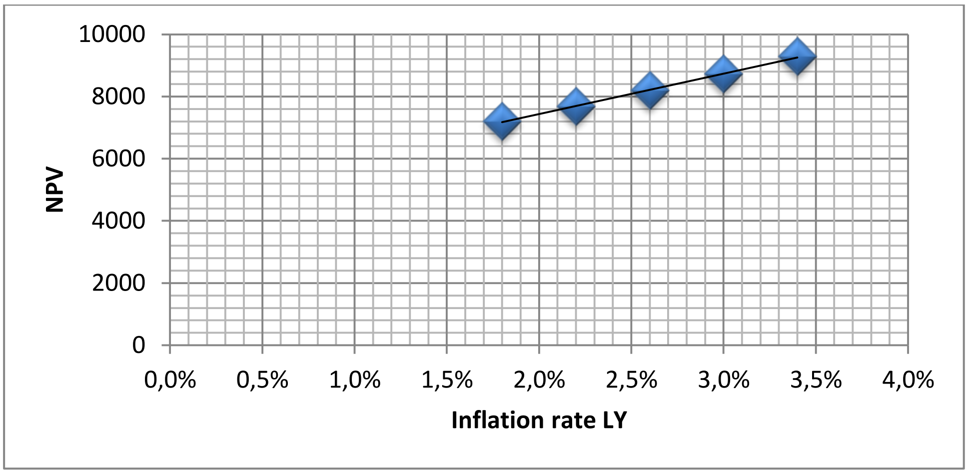

Figure 6. 7: Sensitivity analysis (Inflation rate)

Our results from sensitivity analysis suggest that the expected NPV of out project is most sensitive to the variation in gas prices and inflation rate. While predicted project outcomes is independent from exchange rate.

Chapter 7

CONCLUSIONS AND POLICY IMPLICATIONS

Natural gas is recognised as a desirable energy source and continues to be a sustainable option in the long-term. In view of that and given its huge proved reserves of natural gas, about 55 trillion cubic feet (tcf), Libya has noteworthy prospective position in natural gas market in future. Accordingly, Libya can be an important exporter for natural gas in the Mediterranean Sea region by exporting natural gas to Europe. Also, we expect that natural gas to play more significant role in Libyan economy. However, Libya heavily depends on oil sector and neglects natural gas sector. Libya is one of the five most oil dependent economies in the world, that revenues from oil exports are 95 per cent of government revenue. This makes Libyan economy vulnerable to any instability, not to mention domestic and global profound impact, that dependence on oil both aggravates Libya's current political struggles and increases the risk of further price volatility. This could affect the world stability in future, because totally depending on the price of oil, causing a continued variation in oil prices may lead to further global uncertainty.

This jeopardises country resources, while promising sector such natural gas with high potential is neglected, and not given by Libyan policy makers the enough attention compared with oil sector. In order to avoid that, a policy involves more economic diversification is vital for Libyan decision makers. One attractive option that would have a long-term payoff would be to adopt plans that expand the production by the existing natural gas pipelines and focus more on natural gas industry in order to increase national income share of this sector.

In this chapter, we summarize the research main-questions with the aim of this study and depending on our empirical findings; we provide our conclusions and some policy suggestions.

This study mainly focused on examining the core issues related to transferring natural gas from Libya to Europe with consideration to environmental concerns and CO_2 emissions issues. In this research we also discussed the potential for Italy to be as a bridge for energy between Europe and Africa more specifically by importing natural gas from Libya. We did theoretical and empirical framework to investigate the related issues to our subject and to address the various problems identified by the research.

We invistgated trends of CO_2 emissions refering here to the environmental pollution and tested the impact of some conditional variables on the environmental degradation in the European Union countries. The empirical results of our work showed a strong evidence of convergence in CO_2 emissions among European Union countries with the expected relationship between economic growth and environmental quality in these countries. In addition, we found that energy price is not significant in determining carbon emissions behaviour wherease public awarrence is statically significant and important towards achieving clean environment goals. These findings suggest that CO_2 emissions of EU countries would decline over time, therefore, the EU countries are moving towards environmental sustainability. Accordingly, one can predict more usage of lower emissions fuels would be in future.

Also, we examined how far the economy of Italy has gone in achieving cleaner and environmental sustainability targets put forward by the European Environment Agency. So in order to achieve this objective of our research, we examine the role, interaction and interconnectedness of globalization, energy consumption and real income on CO_2 emissions. The findings from this study help to provide a response to this question. From our empirical results, we found that Italy is not an energy-dependent economy, and economic growth is not causing harm to environment quality. Thus, Italy is immune to environmental pollution, this indicates to a pathway towards achieving environmental sustainability targets. This result is confirmed by the inverse relationship we obtained between globalization and real income on carbon emissions level. In addition, we found that increase in globalization and real income has decreasing impact on environmental pollution. Even with the increase in per capita of energy consumed, CO_2 emissions level of Italy has been declining overtime, hence improvement in environmental quality. Suggesting that Italy energy and environmental policies are in line with their macroeconomic objectives.

The invisible forces of energy demand and supply seems to have been curtailed in such a way that, even without energy conservation policy in place, which is through decrease in energy consumption as the economy grows and become more globalized through trade and foreign investment, the per capita carbon emissions will continue decreasing, thus improvement in environmental quality. Our results suggest that, it is right to conclude that, Italy has achieved a lot in term of sustaining their environment both for the present and generation to come. The position of Italy in terms of environmental quality and sustainability is a lesson to world economies in general that is still lagging behind in their effort to combat environmental pollution. The findings of this study is similar to the findings of Katircioğlu (2014) for Singapore where they argued that environmental conservation policies are well-balanced with macroeconomic targets and Lee and Brahmasrene (2013) for the EU countries. In fact this result supports one of our main arguments in our thesis that Italy can play important role in energy market by importing the Libyan natural gas.

Another important part of this research is to examine the proposition that; it would be financially desirable if Libya expands its production volumes of natural gas in the near future. And therefore, Libya would be able to increases its share of the global gas market by increasing the capacity of the existed pipeline including the new development of Bahr Essalam phase 2. This is going to enhance the production volumes exported via Green Stream pipeline. However, in this study we examine this proposal leaving building new submarines pipelines for further study.

Therefore, one of the main purposes of this study was to determine whether or not expanding the production volumes of natural gas could generate net benefts to the economy and increase the potential of Libya as net exporter of natural gas in the region.

This question was answered by conduting a financial analysis focus on Green Stream Pipeline including the development of Bahr Essalam phase 2 to export natural gas to Europe via Sicily, Italy as case study.

The study findings support that expanding the production of natural gas project is feasible and profitable. The analysis results show that a decision considering expanding the capacity of Green Stream pipeline is viable and financially attractive. And the benefits are expected to increase by more than 70% after Bahr Essalam development compared to increasing the production excluding the recent developments in Bahr Essalam. Therefore, the Libyan government would increase GDP and achieving economic growth and depending more on natural gas industry.

The study finding reveal that the net benefits from natural gas exports are sensitive to changes in gas price. Our sensitivity analysis results show that the NPV for the Green Stream pipeline becomes negative only when the gas price is 3$ per mmbtu or less, whereas the NPV is positive at any price otherwise above that. However these benefits are less sensitive to inflation rate and independent of exchange rate.

The financial analysis results of the natural pipeline confirm that the project is financialy attractive and a decision considering expanding the capacity of Green Stream pipeline the production volume up to 30 bcm/year would generate positive profits. Our findings reveal that recent developments of Bahr Esalam phase 2 increase and doubled the project net benefits more than three times. Therefore, it would be profitable for both Libyan economy and Italy to increase investment in natural gas and particularly increase exports from Libya to Italy via Green stream pipelines, by expanding the capacity for the existent pipeline. Given the previous discussion made in this study in addition to our empirical results, all support the productive future of the Libyan-Italian partnership in natural gas industry.

Policy Implications

The findings of this study are indicative for the government, policymakers and scholars in the field of energy, due to the fact that our results propose important policy suggestions for governments and policy makers that are working towards reducing carbon emissions level and promote sound and cleaner environmental policies.

As the government and policymakers have put in place alternative measure of energy saving technologies to combat CO_2 emissions level and sustain the environment for both the immediate and future generation. The energy and environmental policies set by the EU to fight climate change and replace energy sources for the ones that emit less carbon, tagged targets 2020 which has been recently upgraded to 2030 are in tune with the stated macroeconomic objectives of this region.

From the policy perspective, we suggest Italy has been successful in fighting environmental pollution and sustaining cleaner environment, due to energy conservation policy embarked upon as it well-balanced with the EU climate and energy 2020 targets. Therefore, importing more natural gas will meet the demand of energy in Italy without environment degradation.

Given the previous discussion made in this study in addition to our empirical results, all support that the Libyan-Italian partnership in natural gas industry will continue to grow. Furthermore, a policy involves more economic diversification is vital for Libyan decision makers, and should focus more cooperation with Italy as typical important energy partner. That Italy can be a hub for energy by importing natural gas from Libya. So European countries could add a promising energy provider to its suppliers, and achieve more diversity in gas suppliers and help to reduce European dependence on very limited providers.

The previous analysis concludes the potential for Italy to play important role in European gas market and suggests more flow of Libyan gas resources to the European market without harming to the environment. And in view of our results it would be profitable for both Libyan economy and Italy to increase volumes of exports from Libya to Italy via Green stream pipelines, by expanding the capacity for the existent pipeline and making improvement such Bahr Essalam.

Accordingly, the study suggests the likelihood of Libyan gas resources inflowing the European market. Also puts forward recommendations for EU policymakers to promote greater regional cooperation for the southern Mediterranean, particularly, Libya and support the export potential of this promising supplier for gas. A major finding can be, also, concluded from this study, is that the prospective for natural gas to play more significant role in Libyan economy, therefore, another way for well-usage of the country natural resources.

However, due to the current civil war in Libya, we depended on secondary sources of our data, also, limited our assesment to the financial analysis so economic analysis was not achievable due to the lack of information and left it to further studies in future. Likewise, althogh this study shed the light to the importance of natural gas sector in Libya, more studies are needed to evaluate similar pipelines to export natural gas from Libya to Europe via other potential destinations Malta, Greece and assessing options for exporting LNG as well.

REFERENCES

[1] Criado C. O. and J.M. Grether (2011). Convergence in per capita CO2 emissions: A robust distributional approach. *Resource and Energy Economics* 33: 637-665.

[2] Center for Climate and Energy Solution, Report (June 2013). Leveraging Natural Gas to reduce Greenhouse Gas Emissions. Retrieved from https://www.c2es.org/document/leveraging-natural-gas-to-reduce-greenhouse-gas-emissions/2/

[3] De Oliveira G. and G. De Vargas Mores, (2015). Convergence in per capita carbon dioxide emissions: a panel data approach. Working Papers, Department of Economics 2015_35, *University of São Paulo* (FEA-USP). Series No, 2015-35.

[4] Moreno, Juan & Padilla, Emilio. (2011). Cross-Country Polarisation in CO2 Emissions Per Capita in the European Union: Changes and Explanatory Factors. *Environmental and Resource Economics. 54.* 10.1007/s10640-012-9607-x.

[5] Akadiri, S.S., Lasisi, T.T., Uzuner, G., Akadiri, A.C., (2018). Examining the causal impacts of tourism, globalization, economic growth and carbon emissions in tourism island territories: bootstrap panel Granger causality analysis. *Current Issues in Tourism*, 1–15.

[6] Akadiri, A.C., Saint Akadiri, S., Gungor, H., (2019). The role of natural gas consumption in Saudi Arabia's output and its implication for trade and environmental quality. *Energy Policy* 129, 230–238.

[7] Ezcurra R., (2007). Is there cross-country convergence in carbon dioxide emissions?, *Energy Policy 35*: 1363-1372.

[8] Gaulier G., C. Hurlin and P. Jean-Pierre, (1999). Testing Convergence: A Panel Data Approach, *Annales d'Economie et de Statistique*: 411-427.

[9] Gerald Carlino and Leonard Mills. (1996). Are U.S. regional incomes converging? Reply. *Journal of Monetary Economics, 38*, 599-601.

[10] Kounetas, K. Elias, (2018). "Energy consumption and CO2 emissions convergence in European Union member countries. A tonneau des Danaides?," *Energy Economics*, *69*(C), 111-127.

[11] Michael B. Loewy and David H. (1996). Papell, Are U.S. regional incomes converging? Some further evidence. *Journal of Monetary Economics 38*. 587-598.

[12] Jalil S. A., (2016). Per Capita Carbon Dioxide Emission in the Developing Economies: Convergence or Divergence?. *Journal of International Business, Economics and Entrepreneurship* e-ISSN: 2550-1429, 1 Dec 2016, 1-8.

[13] Jobert T., F. Karanfil and A. Tykhonenko, (2010). Convergence in carbon dioxide emissions in the EU: Legend or reality?. *Energy Economics*, *32*, 6, Nov. 1364-1373.

[14] Joerg Breitung, (2015). The Analysis of Macroeconomic Panel Data. *The Oxford Handbook of Panel Data*. DOI: 10.1093/oxfordhb/ 9780199940042.013.0015.

[15] Joseph E. Aldy, 2006. Per Capita Carbon Dioxide Emissions: Convergence or Divergence?, *Environmental and Resource Economics 33*: 533-555.

[16] Im K. S., M. H. Pesaran and Y. Shin, (2003). Testing for unit roots in heterogeneous panels, *Journal of Econometrics* 115. 53-74.

[17] Katircioğlu, S. T. (2014). Testing the tourism-induced EKC hypothesis: The case of Singapore. *Economic Modelling*, 41, 383-391.

[18] Lin J., R. Inglesi-Lotz and T. Chang (2018). Revisiting CO2 emissions convergence in G18 countries, *Energy Sources, Part B: Economics, Planning, and Policy*, 13:5, 269-280, DOI: 10.1080/15567249.2018.1460422.

[19] Lee, J.W., Brahmasrene, T., (2013). Investigating the influence of tourism on economic growth and carbon emissions: evidence from panel analysis of the European Union. *Tourism Management. 38*, 69–76.

[20] Ramesh Das, (2013). CO2 Emissions in India: Are the States Converging?. Beykent University, *Journal of Social Sciences 6*, 2, 2013. ISSN: 1307-5063.

[21] Romero-Avila D. (2008). Convergence in carbon dioxide emissions among industrialized countries revisited. *Energy Economics 30*: 2265-2282.

[22] S. Acar, P. Söderholm and R. Brännlund (2018). Convergence of per capita carbon dioxide emissions: implications and meta-analysis, *Climate Policy, 18:*4, 512-525, DOI: 10.1080/14693062.2017.1314244.

[23] Strazicich M., J. A. List, (2003). Are CO_2 Emission levels converging Among Industrial Countries? , *Environmental and Resource Economics 24*: 263-271.

[24] Yazdi S. and Shakouri B. (2018). The renewable energy, CO2 emissions, and economic growth: VAR model, *Energy Sources, Part B: Economics, Planning, and Policy*, *13:1*, 53-59, DOI: 10.1080/15567249.2017.1403499.

[25] Dilaver O, Dilaver Z. and Hunt L. (2013).. What drives natural gas Consumption in Europe? Analysis and Projections. SEEC 143, *University of Surrey*, October 2013 ISSN 1749-8384.

[26] Hafner, M. and Tagliapietra, J. (2013). The globalization of natural gas markets; new challenges and opportunities for Europe. *European energy studies*. Claeys & Casteels Publishing, Leuven, Belgium.November 15. ISBN-13: 978-9491673160.

[27] International Energy Agency (IEA), Natural Gas Information, various issues. Retrieved from www.iea.com.

[28] International Energy Agency (2016). Energy Policies of IEA Countries. Retrieved from http://www.iea.org/publications/freepublications/publication/energy-policies-of -iea-countrie-italy-2016-review.html.

[29] International Energy Statistics (2017). Retrieved from https://knoema.com/EIAIES2017AUG/ international- energy-statistics-monthly-update?location=1001600-Libya.

[30] IHS 2016. IHS Economics Report (2016). The Economic Benefits of Natural Gas Pipeline Development on the Manufacturing Sector. May 2016.

[31] Lochner S. and Dieckhoner C. (2012). Civil Unrest in North Africa Risks for natural gas supply?, *Energy Policy*, 2012, vol. 45, issue C, 167-175.

[32] Ministero dello Sviluppo Economico (Ministry of Economic Development), (2013). National Energy Strategy: for a more competitive and sustainable energy. Retrieved from http://www.sviluppoeconomico.gov.it/images/stories/documenti/SEN_EN_marzo2013.pdf.

[33] Mott Mac. Donald M. Report, (November 2010). Supplying the EU Natural Gas Market. Retrieved from www.mottmac.com.

[34] Manuel M. (2011). Europe's energy future: natural gas supply between geopolitics and the markets: Work package I - The future role of natural gas - trends and projections for demand and supply in 2030. Retrieved from http://nbn-resolving.de/urn:nbn:de:0168-ssoar-394225.

[35] Stern J. (2014) Reducing Dependence on Russian Gas: distinguishing natural gas security from geopolitics, *Oxford Institute for Energy Studies OIES PAPER*: NG 92 Oct.

[36] The U.S. Energy Information Administration, Country Analysis Briefs, several issues. (EIA). Retrieved from https://www.eia.gov/todayinenergy/detail.php?id=590.

[37] Talus k. (2011) Long-term natural gas contracts and antitrust law in the European Union and the United States. *Journal of World Energy Law and Business*. *4*, 3.

[38] Macmillan S. 2013. Gas to Coal competition in the U.S. Power Sector, *International Energy Agency*. Retrieved from www.iea.org.

[39] Stern J. 2015 The Geopolitics of Gas in Europe: conflicts between political correctness and natural gas analysis EPRG and CEEPR. *European Energy Policy Conference*, London, July 10.

[40] Paltsev, S., F. O'Sullivan, N. Lee, A. Agarwal, M. Li, X. Li, N. Fylaktos (2013) Natural Gas Monetization Pathways for Cyprus: Interim Report - Economics of Project Development Options, MIT Energy Initiative, *Massachusetts Institute of Technology*, Cambridge, MA.

[41] Stern D. (2004). The Rise and Fall of the Environmental Kuznets Curve. *World Development*, 32 (8): 1419–1439.

[42] Rainer Seele 2011, BASF Road show Oil & Gas, November 21, 2011, Frankfurt. Retrieved from https://www.basf.com/documents/ corp/en/investor-relations/calendar-and-publications/presentations/2011/ 111121_BASF_RS_Oil-Gas.pdf.

[43] Hafner M. and Tagliapietra S. 2013. Rethinking Global Natural Gas Markets: new Challenges and Opportunities Ahead. *Review of Environment, Energy and Economics* - Re3, 2013.

[44] Charles F. Mason and Neil Wilmot. (2014). Jump Processes in Natural Gas Markets, *Energy and Climate Economics, CESIFO working paper No*. 4604, 10:. www.cesifo-group.de.

[45] Eurostat report (2016). Retrieved from http://ec.europa.eu/eurostat/statistics-explained/ index. php/

[46] Natural_gas_consumption_statistics (2013). *Oil and Gas Journal*, Retrieved from http://www.ogj.com.

[47] Annicchiarico B., Bennato A. & Chini E. (2014). 150 Years of Italian CO2 Emissions and Economic Growth. *CREATES Research Paper* 2014-2 Denmark.

[48] Bilgili F., E. Koçak & Ü. Bulut (2016). The dynamic impact of renewable energy consumption on CO2 emissions: A revisited Environmental Kuznets Curve approach. *Renewable and Sustainable Energy Reviews, 54*, 838–845.

[49] Boden, T.A., G. Marland, & R.J. Andres. (2011). Global, Regional, and National Fossil-Fuel CO_2 Emissions. *Carbon Dioxide Information Analysis Center, Oak Ridge National.*

[50] Carraro C. Sgobbi A. (2008). Climate Change Impacts and Adaptation Strategies in Italy. An Economic Assessment. *University of Venice*, *Fondazione Eni Enrico Mattei*, 6.January 2008. Italy. Retrieved from http://www.feem.it/Feem/Pub/Publications/WPapers/default.htm

[51] Edoardo B. Zane. (2014 January). Assessment of climate change policies in the context of the European Semester Country Report: Italy. *Ecologic Institute* Report 2014.

[52] Ente Nazionale Per L' Aviazione Civile (ENAC). (2012 June). Italy's Action Plan on CO_2 Emission Reduction. *Report 2012*. Italy.

[53] European Commission. (2015, November). Towards an Energy Union: Country Factsheet Italy. *SWD* (2015) 229.

[54] European Environment Agency (2016). Country Profile: Trends and projections in Italy: Tracking progress towards EU Member States' climate and energy targets. *EEA*.

[55] Bölük G. & M. Mert. (2015). The renewable energy, growth and environmental Kuznets curve in Turkey: An ARDL approach. *Renewable and Sustainable Energy Reviews 52*: 587–595.

[56] Institute for Environmental Protection and Research (ISPRA). (2014). Italian emission inventory 1990-2012. Informative Inventory Report, ISPRA. 201/2014.

[57] Kuznets, S. (1955). "Economic Growth and Income Inequality." *American Economic Review 45*(1):1-28.

[58] Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A. DOI 10.3334/CDIAC/00001_V2011.

[59] Kais Saidi & Sami Hammami. (2015). The impact of CO2 emissions and economic growth on energy consumption in 58 countries. *Energy Reports 1* (2015) 62–70.

[60] Lacheheb M.; A. S. Abdul Rahim & A. Sirag (2015). Economic Growth and Carbon Dioxide Emissions: Investigating the Environmental Kuznets Curve Hypothesis in Algeria. *International Journal of Energy Economics and Policy*, *5* (4): 1125-1132.

[61] Lee C.C., C.P. Chang. (2009). Stochastic convergence of per capita carbon dioxide emissions and multiple structural breaks in OECD countries. *Economic Modeling*, *26* (6):1375-1381, doi:10.1016/j.econmod.2009.07. 003.

[62] Muhammad Shahbaz, Smile Dube, Ilhan Ozturk & Abdul Jalil. (2015). Testing the Environmental Kuznets Curve Hypothesis in Portugal. *International Journal of Energy Economics and Policy*. *5* (2), 475-481. ISSN: 2146-4553.

[63] Muhammad Shahbaz a,n, IlhanOzturk b,1, TalatAfza c. & AmjadAli. (2013). Revisiting the environmental Kuznets curve in a global economy. *Renewable and Sustainable Energy Reviews. 25*. 494 – 502.

[64] Muhammad Shahbaz, Saleheen Khan, Amjad Ali & Mita Bhattacharya (2015). The Impact of Globalization on CO2 Emissions in China. *MPRA Paper No. 64450*, posted 18. May 2015 17:00 UTC.

[65] Muhammad Shahbaz, Syed Jawad Hussain Shahzad & Mantu Kumar. (2017). Is Globalization Detrimental to CO2 Emissions in Japan? New Threshold Analysis. *MPRA Paper No. 82413*, posted 7 November 2017 19:29 UTC.

[66] Nuno Carlos Leitão. (2014). Economic Growth, Carbon Dioxide Emissions, Renewable Energy and Globalization. International Journal of Energy *Economics and Policy 4* (3), 391-399.

[67] Organisation for Economic Co-operation and Development (OECD). (2013). Environmental Performance Reviews: Italy. *OECD Press*.

[68] Ozturk, I. & Acaravci, A. (2010). CO2 emissions, energy consumption and economic growth in Turkey. *Renewable and Sustainable Energy Reviews 14* (9), 3220-3225.

[69] Özokcua S., Ö. Özdemir. (2017). Economic growth, energy, and environmental Kuznets curve. *Renewable and Sustainable Energy Reviews*, 72: 639–647.

[70] Sek, S. K. (2010). Testing stochastic convergence of carbon dioxide emissions in Malaysia, International Conference on Chemistry and Chemical Engineering, *ICCCE 2010*. 241-244.

[71] Noceraa S. & Federico Cavallaro. (2011). Policy Effectiveness for containing CO_2 Emissions in Transportation. *Procedia Social and Behavioral Sciences, 20* (2011) 703–713.

[72] Virdis, M.R. (IDDRI). (2015)The Institute for Sustainable Development and International Relations Pathways to deep decarbonization in Italy, *SDSN – IDDRI.* ISBN: 978-2-9554689-1-3

[73] Salci, Sener and Jenkins, Glenn (2016): Incorporating Risk and Uncertainty in Cost-Benefit Analysis. Development Discussion Paper: 2016-09. Online at https://mpra.ub.uni-muenchen.de/74161/ *MPRA Paper No. 74161*, posted 1 October 2016 15:51 UTC

[74] Glenn P. Jenkins & Mikhail Miklyaev & Brian Matanhire & Primrose Basikiti & Shahryar Afra & Mostafa Shahee, (2018). "The Cost- Benefit Analysis for Resilience in the Sahel Enhanced on Vulnerable households in Burkina Faso and Niger," *Development Discussion Papers* 2018-10, JDI Executive Programs.

[75] Glenn P. Jenkins & Mikhail Miklyaev & Gift Khozapi & Elly Preotle, (2018). "Cost Effective Analysis of Interventions in Nigeria to Provide Access to Potable Water, Sanitation Services and to Promote Exclusive Breast Feeding Practices," *Development Discussion Papers* 2018-01, JDI Executive Programs.

[76] Glenn P. Jenkins & Mikhail Miklyaev & Brian Matanhire & Gift Khozapi, (2018). "Cost- Benefit Analysis of Zimbabwe for a Sustainable Poverty

Reduction and Improvement of Food, Security, Nutrition and Hygiene Practices," *Development Discussion Papers* 2018-07, JDI Executive Programs.

[77] Antonio Michelon, Angus Paxton and Fotis Thomaidis, (2017). Cost- Benefit Analysis of STEP, as first phase of MIDCAT- final report 17 November 2017.DOI 10.2833/65894.

[78] Baurzhan, S., & Jenkins, G. P. (2016). Off-grid solar PV: Is it an affordable or appropriate solution for rural electrification in Sub-Saharan African countries?. *Renewable and Sustainable Energy Reviews*, *60*, 1405-1418. Sustainability 2017, 9, 372; DOI; 10.3390/su9030372.

[79] European Commission. (2006) "Guidance on the methodology for carrying out cost - benefit analysis", *Working Document .4, DG for Regional Policy*, http://ec.europa.eu/regional_policy/index_en.htm.

[80] Ivan Zayas, Gloria De Paoli, Florimond Brun, Verena Mattheib.(2016). D4.3 CBA approach suited for water reuse schemes. *DEMOWARE GA No*. 619040. Retrieved from www.demoware.eu

[81] Kjell Hausken. (2015). Cost-benefit analysis of war. International Journal of Conflict Management *IJCMA* 27,4. October 2016. DOI: 10.1108/IJCMA-04-2015-0023.

[82] Francesco Angelini. report July (2011). Economic Analysis of Gas Pipeline Projects. JASPERS Knowledge Economy, Energy and Waste Division *JASPERS Staff Working Papers*.

[83] Ali Aissaoui. (2016). Algerian Gas: Troubling Trends, Troubled Policies OIES PAPER: NG 108 .*Oxford Institute for Energy Studies* ISBN 978-1-78467-058-0.

[84] OPEC, Retrieved from http://www.opec.org.

[85] Mellitah Oil & Gas B.V. (2017), Libyan Gas Company. Retrieved from www.mellitahog.ly.

[86] Global Information and Technology Company, *Bloomberg* (2016). Retrieved from https://www.bloomberg.com/news/articles/2019-04-04/algeria-politics-hits-oil-trading-deals-from-athens-to-geneva.

[87] ENI report (2017). Retrieved from https://www.eni.com/enipedia/en_IT/news-archive/operations/enis-activities-in-libya-update-to-february-26th-2011.page?lnkfrm=enipedia.

[88] IGUN (International Gas Union) Report (2012).

[89] WINGAS, A secure energy supply for Europe, Report 2016. Retrieved from https://www.wingas.com/en/raw-material-natural-gas/where-does-europe-get-its-natural-gas.html

[90] International Statistics, Report (2016). Retrieved from https://www.iea.org/topics/ naturalgas/

[91] World Bank. Retrieved from https://data.worldbank.org/country/italy.

[92] World data atlas and international energy statistics Jan.2016. Retrieved from http// knoem.com

[93] Eurogas, Marcogaz and GERG Report 2014. Gas: The right choice for heating in Europe. Sep. 2014. Retrieved from http://www.eurogas.org/uploads/ media/Gas__the_right_choice_ for_heating_in_Europe_PART_II_Brochure_ 140814.pdf.

APPENDICES

Appendix A: CBA Analysis of Green Stream-Natural-Gas Pipeline Project (Libya to Italy)

One of the main purposes of this dissertation is to conduct Feasibility Analysis with Sensitivity analysis by carry out a financial appraisal of Green Stream pipeline, including the new Bahr Essalam development, to export natural gas from Libya to Italy.

Two main scenarios:

- Increasing the production volume excluding the developments of Bahr Essalam Phase 2
- Increasing the production volume including the developments of Bahr Essalam Phase 2

Features of Bahr Essalam Phase II development

- Includes the completion of 10 wells.
- Phase I consisted of drilling 26 wells which were put into production in September 2005.
- Phase II, now in the development phase, consists of drilling 10 wells.
- The gas and condensate are produced from 15 platform wells and 11 subsea wells divided in two clusters located 20 and 25km away from Sabratha platform.
- The production from the subsea and platform wells is treated on Sabratha platform for separation and dehydration. The condensate is pumped through a 10in pipeline to Mellitah for further treatment and export. The gas is transported through a 36in pipeline to the Mellitah plant for final treatment

and onward transmission to the local market and export to Italy through the Green Stream compression station and 540km 32in sea line.

Bahr Essalam phase 2	This is a development for natural gas field, which is operated by Mellitah Oil & Gas B.V. Libyan Branch, a consortium between National Oil Corporation and ENI North Africa, will be tied back to the Sabratha platform

* Bah Essalam devlopment		
Pipeline offshore Distance	(km)	110
startıng date		2018
purpose	Modifications to the Sabratha platform	
cost	$	500 million
additional production	12.6 mmcm/d	4599mmcm/y

Some Other project inputs:(Green stream)		
Onshore Section		
Pipeline Diameter	(inch)	32
Pipeline Distance	(km)	550
Pipeline thickness	(mm)	14,3
Offshore Section		
Pipeline Diameter	(inch)	32
Pipeline Distance	(km)	520
Pipeline thickness	(mm)	28

- Weighted average cost of capital (WACC) is calculated as:

WACC = Cost of Equity _ Market Capitalization/(Market Capitalization _ Total Debt) _
Cost of Debt _ Total Debt/(Market Capitalization _ Total Debt) _ (1 – Corporate tax rate)

And,
Cost of Equity = Interest rate _ Equity Risk Premium _ Company Beta
Cost of Debt = Company bond yield _ geopolitical risk premium

WACC as used in similar studies for similar projects by MIT (2013) and Mac Donald (2010).

Note: the above method is used in (MOTT Mac Doland. 2010)

Data source

- https://www.epmag.com/bahr-essalam-2-gathers-pace-libya-824251
- http://gascompressionmagazine.com/2016/06/06/technip-lands-mediterranean-sea-contract/
- Gas Price: used in IEA projections for gas price in Europe and Asia, Europe average border natural gas price between current 4,5 and historical natural gas price 6,6 (Federal Reserve Economic Data)
- http: knoema.com/atlas/Libya
- EIA-Libya country energy profile
- Alexander's Gas & Oil Connections. 2004-10-08. Retrieved 2009-07-29.
- https://www.revolvy.com/main/index.php?s=Greenstream%20pipeline&item_type=topic
- feed gas cost , Tax & WACC are from secondary sources for similar studies regard pipelines in the regain: MIT, MOTT Mac Doland. 2010
- pipeline capacity: bcm/y: ttp://www.wiki30.com/wa?s=Greenstream_pipeline
- renewed contract for Gas until 2047: www. oilvoice.com

Appendix B: inverted (U-Shaped) EKC Test for Italy

Table1: Results of EKC test (U-SHAPED) EKC

Dependent Variable: LCO2
Method: ARDL

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LCO2(-1)	0.483827	0.105140	4.601741	0.0000
LEC	0.919674	0.131493	6.994107	0.0000
LRGDP	**-0.401989**	**0.099384**	**-4.044795**	**0.0002**
$LRGDP^2$	**0.017850**	**0.004101**	**4.352965**	**0.0001**
LGLOB	-0.928546	0.150000	-6.190306	0.0000

R-squared	0.950556	Mean dependent var	1.942497
Adjusted R-squared	0.945485	S.D. dependent var	0.105953
S.E. of regression	0.024739	Akaike info criterion	-4.454264
Sum squared resid	0.023868	Schwarz criterion	-4.251515
Log likelihood	102.9938	Hannan-Quinn criter.	-4.379075

*Note: p-values and any subsequent tests do not account for model selection.

The inverted U-shaped EKC relationship is not exist here.

Table 6.2: Cross-sectional tests for conditional convergence in the average annual rate of growth in per capita CO_2 emissions among European Union's countries (N=21): extra OLS estimation for conditional variables

Eq no	α	$lnCO2pci1980$ $\beta1$	$lnGDP$ $\beta2$	$lnGDP\char`^2$ $\beta3$	$\ln GasolineP$ $\beta4$	$ln\ Population$ $\beta5$	Temp $\beta6$
1	0,019 (5.51)	-0.020 (-5.40)	-	-	-	-	-
	R^2	0.61		F	29.20		
2	-0.010 (-0.69)	-0.022 (-6.18)	0.007 (2.05)	-	-	-	-
	R^2	0.68		F	19.16		

3	0.005 (0.635)	-0.022 (-6.2)	-	0.001 (2.07)	-	-	-
	R^2	0.68		F	19.27		
4	0.02 (3.22)	-0.020 (-5.20)	-	-	0.0004 (0.021)	-	-
	R^2	0.61		F	13.84		
5	0.039 (4.64)	-0.02 (-6.095)	-	-	-	-0.003 (-2.52)	-
	R^2	0.71		F	21.92		
6	0.013 (3.19)	-0.014 (-3.11)	-	-	-	-	0.0004 (2.25)
	R^2	0.69		F	20.24		