PRICING AND GEOPOLITICS IN INTERNATIONAL GAS TRADE

…could the Gas Exporting Countries Forum unify price regimes?

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LIST OF ABBREVIATIONS

AB	Atlantic Basin
ABLTM	Atlantic Basin LNG Trade Model
BP	British Petroleum
Bcf/d	Billion Cubic Feet per Day
CCGT	Combined Cycle gas Turbine
CIEP	Clingendael International Energy Programme
CNG	Compressed Natural Gas
CEPMLP	Center for Energy, Petroleum and Mineral Law and Policy
CHP	Combined Heat and Power Plants
CFP	Compagnie Francaise des Petroles
COMECON	Council for Mutual Economic Assistance
DOE	Department of Energy
EEC	European Economic Commission
EIA	Energy Information Administration
EU	European Union
FERC	Federal Energy Regulatory Commission
FSU	Former Soviet Union
GECF	Gas Exporting Countries Forum
GHG	Green House Gas
GTL	Gas to Liquid
GIIGNL	Groupe International des Importateursde Gaz Natural Liquéfié
IEA	International Energy Agency
IOCs	International Oil Companies
IOGCs	International Oil and Gas Companies
IPE	International Petroleum Exchange
IQPC	International Quality and Productivity Centre
JCC	Japanese Crude Cocktail
LDC	Local Distribution Companies
LNG	Liquefied Natural Gas
MMcf	Million cubic feet
MRP_{LNG}	Marginal Revenue Product of LNG
MEES	Middle East Economic Survey
NEB	National Energy Board

OAPEC	Organization of Arab Exporting Countries
OECD	Organization for Economic Co-operation and Development
OGEC	Organization of Gas Exporting Countries
OIES	Oxford Institute for Energy Studies
OPEC	Organization of Petroleum Exporting Countries
PB	Pacific Basin
SPA	Sales and Purchase Agreement
TOP	Take-or-Pay
UK	United Kingdom
UN	United Nations
UP	Uniform Pricing
UPM	Uniform Pricing Mechanism
US	United States
VC	Volume Control
VCM	Volume Control Mechanism
WEF	World Energy Forum
WTO	World Trade Organization

DEDICATION

To

Almighty GOD

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ABSTRACT

Market-based pricing for Liquefied Natural Gas (LNG) may be less remunerative or uncertain for exporters in the evolving market. The possibility of rent-maximizing could encourage them to collude through an influence mechanism. This book examined the feasibility of Uniform Pricing (UP) or Volume Control (VC) in the Atlantic Basin and analyzed the consequences of such a development on LNG trade. So far, no existing model specifically considers the sustainability and effects of an LNG exporters' cartel. Neither has any research on the application of uniform pricing in international gas trade been undertaken. This work filled this gap through the Atlantic Basin LNG Trade Model. By fitting the historical data and iterating the objective function with the same number of random samples (using Palisade software), a probability distribution of market share, price and revenue outcomes were generated. From these distributions of outcomes, the most probable scenario for each exporter was extracted and subsequently, contextualized.

The exercise reveals a significant change in revenue and market share favourable to a few countries – Algeria, Nigeria, and Qatar. Qatar (or perhaps Algeria) is the key country which could lead any such price/volume setting process. However, unless the UP/VC induced-price is low enough to undercut the cost of developing shale gas, the mechanisms are unsustainable in North America. In Europe, the UK is similar to the US, while Spain and possibly France could be amenable to UP and VC. To some extent, UP is present in the Pacific Basin (PB) as Japanese Crude Cocktail (JCC) - but not as a "producer price policy". However, with the globalization of LNG trade, it is not possible to separate the two geographical and commercial parts of the global LNG market. It is therefore, likely that LNG exporters could determine price in some markets by adopting UP and VC, while indirectly influencing other markets. Meanwhile, there are sufficient grounds for further research in this regard.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Man's overwhelming dependence on carbon fuels makes their affordability and sustainability, vis-à-vis climate change a great concern.[1] Energy demand patterns are gradually responding to environmental concerns, as well as, new technologies. So far gas[2] has become the chosen clean-burning fuel used for space heating, generating electricity and fuelling industries - varying from plastics and petrochemicals to fertilizer production.

As the bridge[3] to hydrogen fuel cells, it is powering many bus fleets and could reduce CO_2 emissions by 40%.[4] Due to increased consumption, natural gas has become one of the primary sources of energy globally (see Figure 1.1). Consequently, international trade in gas increased by 5.2% annually from 2000 to 2005[5] and by 3% in 2008.[6] While it may be unrealistic to predict the potential effects of the current economic crunch on gas production and consumption, a trend is foreseeable and "*production capacity would be there to meet demand".*[7] By 2005 global gas production had more than doubled the 1970 volume due to increased demand.[8] However, it is trade in the form of Liquefied Natural Gas that has contributed immensely to the increase in cross border gas trade.

From a rigid set of trades in a relatively limited number of countries, predominantly in the Pacific Basin, LNG trade has grown. In most regions, efforts to solve problems with traditional sources of gas supply have made LNG

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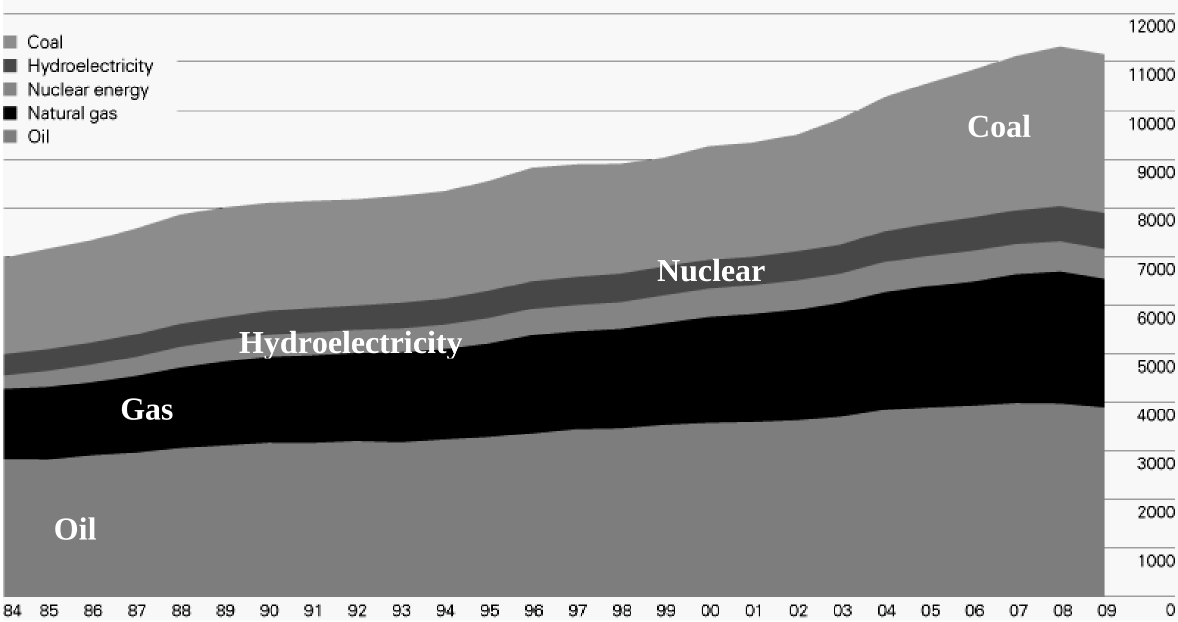
[1] Odell, P; Why Carbon Fuels will dominate the 21st Century's Global Energy Economy, 2004.
[2] **Gas, in this book, covers both Pipeline and Liquefied Natural Gas (unless when explicitly distinguished). Natural Gas simply means Pipeline gas.**
[3] Gas has the highest hydrogen content of all fossil fuels.
[4] According to the US DOE, Natural Gas Vehicles emit 40% less CO_2 than gasoline-powered cars.
[5] IEA, Natural Gas Market Review 2006: Towards a global gas market. Page 31, (Paris: OECD/IEA, 2006).
[6] CEDIGAZ, *2008 natural Gas Year in Review*, Press Release, May, 2009
[7] Sandrea, I., *What is next for the oil and gas industry?* OEF, February 2009.
[8] Victor et'al, (ed.s) Natural gas and geopolitics: from 1970 to 2040, 2006.

a valuable option.[9] For instance, OECD countries accounted for 87.62% of total LNG volumes traded in 2007.[10] Consequently, LNG trade grew[11] from 6% of international gas trade[12] in 1970 to 29% in 2007.[13]

Figure 1.1 World Primary Energy Consumption (1982-2009 Mtoe)[14]



Historically, the pace of LNG trade growth, relative to global gas demand and trade, is evident in Table 1.1 overleaf. At different times between 1995 and 2005 LNG's growth rate doubled the growth rate of gas demand.[15] From 2004 to 2008, LNG trade has grown steadily – 6% per annum – while pipeline gas trade has grown at 3.3% per annum.[16] However, in 2008, as a share of international gas trade, pipeline gas trade rose by 4.2% while LNG fell to 24.2% from 25%.[17]

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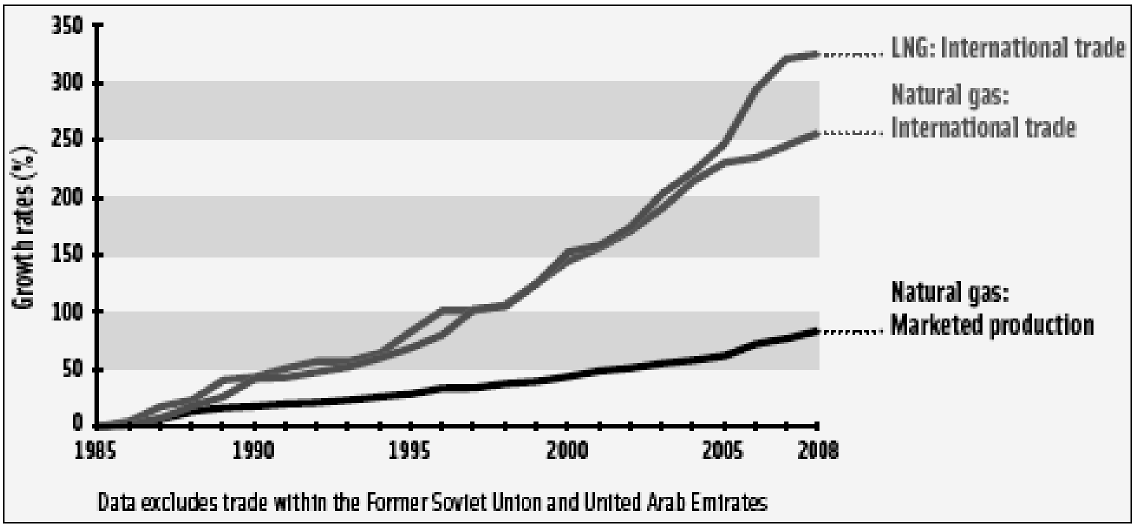
[9] The trend in various countries or Basins has been different. Therefore, to adequately set the scene for the study, Chapter Two also shows the role of natural gas in global energy balances and specifically, in the Atlantic Basin countries.
[10] BP *Statistical Review of World Energy 2008*
[11] The history of how LNG trade has evolved in Europe, North America and the Pacific Basin is presented in Chapter Two.
[12] Chabrelie, M., *LNG: A Commodity in the Making*, PANORAMA 2006
[13] B.P., *Statistical Review of World Energy*, June, 2010.
[14] BP *Statistical Review of World Energy 2008*
[15] This has been the case and even more so in the years 1997 to 2007.
[16] CEDIGAZ, *2008 natural Gas Year in Review*, Press Release, May, 2009
[17] *Ibid*

LNG trade grew steadily in the first 25 years (as Figure 1.2 shows), but faster in the Pacific Basin and slower in the Atlantic Basin.

Figure 1.2 Growth in Gas Trade[18]



However, in the last fifteen years the situation has been changing: LNG trade has grown more rapidly in the Atlantic than in the Pacific. In addition, contract flexibility, delivery swaps, short-term/spot transactions in LNG trade have soared: the volume of swapped LNG increased from 0.42Bn m^3 in 2005 to 9.5Bn m^3 in 2007, while spot LNG transactions now account for 15%[19] of total LNG trade.[20]

Table 1.1 Percentage change[21] in Gas Trade globally relative to demand (1995-2008)

Global growth rate in:	1995	2000	2005	2008
Gas demand	2.5%	4.8%	2.3%	2.5%
Gas trade	4.1%	8.6%	6.4%	4.0%
Pipeline gas trade	11.5%	8%	6.4%	4.2%
LNG Trade	3.9%	10.3%	6.4%	-0.5%[22]

Source: Extracted by author from BP Statistical Review of World Energy; US EIA and CEDIGAZ

[18] GIIGNL, *The LNG industry*, 2008
[19] As at February 2009, this figure was triple the share in 2000.
[20] Wietfeld, A, and Fenzl, N., *LNG Trading: Overview and Challenges*. OEF, February 2009.
[21] Growth here refers to percentage change in volume of gas traded/consumed in one year over the preceding year. So, growth is relative and could be due to either a significant increase (in volume) during a particular year (t) or a low volume in the previous year (t-1) or a combination of both factors.
[22] This is in sharp contrast with an average increase of 7.8% per annum from 1982 to 2007 – according to CEDIGAZ, *2008 natural Gas Year in Review*. Press Release, May, 2009.

Among other factors, the LNG boom has also been due to:

- Stranded gas becoming economically viable as a result of better price incentives
- Fall in costs[23] due to technological innovations
- Liberalization of gas and electricity markets in North America and Europe
- Change in supply situation of USA and the UK, as well as, favourable regulatory developments[24] and the need for diversity of supply

These factors have significantly affected gas demand but, more important is their effect on the supply market. The market is changing with more players in different segments of the LNG supply chain and some concentration of suppliers is expected given the present trend. For instance, huge investments in supply infrastructure have been made in the Middle East and Africa. Based on existing projects, Qatar and Nigeria would be the largest producers of LNG in the world by 2015 with 98bn m^3 and 45bn m^3 capacity respectively.[25] From the Pacific Basin (as Table 1.2 shows), the demand centre for LNG is projected to move to the Atlantic Basin[26] with potential increase in imports.[27]

Table 1.2 Growth in Gas demand and LNG Trade: Atlantic vs Pacific (1995-2008 in Bcm)

Growth in Gas demand	1995	2000	2005	2008
Atlantic Basin				
- Europe (EU)	6.9%	3.6%	2.0%	1.6%
- North America[28]	4.1%	5.1%	-1.2%	1.3%
Pacific Basin (Asia Pacific)	4.8%	7.8%	7.8%	5.9%
Growth in LNG Trade				
Atlantic Basin				
- Europe	9.1%	18.9%	18.9%	3.7%
- USA	-64.7%	36.5%	-3.2%	-54.4%
Pacific Basin	3.9%	6.4%	3.2%	5.4%
Growth in Pipeline gas trade				
Atlantic Basin				
- Europe	12%	8%	7.5%	5.0%
- USA	9.6%	5.8%	2.1%	-4.1%
Pacific Basin	26.4%	0%	1.7%	-1.4%

Source: Extracted by author from BP Statistical Review of World Energy; US EIA and CEDIGAZ

[23] The reduction in cost along the value chain ended in 2004 and subsequently the trend has been reversed due to construction capacity constraint and rising cost of raw materials (especially Steel).
[24] Specific regulatory regimes and incentives for LNG in different countries are discussed in Chapter Two.
[25] Wietfeld, A, and Fenzl, N., *LNG Trading: Overview and Challenges*. OEF, February 2009.
[26] This is one of the reasons for focusing the research on the Atlantic Basin LNG market. Other reasons are stated in section 1.5 below.
[27] Tables 2.1 and 2.2 (in Chapter Two) present a more detailed picture of how the top five LNG exporters and have changed since 1995.

The widespread adoption of LNG is creating changes that portend newer challenges for gas (especially LNG) trade. Moreover, as trade develops, the pricing mechanism will evolve.[29] Apparently, the intermittent de-linking of gas prices from oil observed in some markets and evolution of spot LNG trade would bring additional issues[30].

Initially, the industry was more concerned with finding a market. Now the market is readily available (as Figure 1.3 shows) and its dynamic structure has been shifting risks,[31] although the implications for suppliers were not obvious during the era of high oil and gas prices. Effects of the changing risk profile could become more evident, however, in a low price dispensation.

Figure 1.3 International spread of LNG trade

Import	Atlantic	Pacific
1964- 2000	United Kingdom (1964-1994), France (1964), Spain (1969), Italy (1969), United States (1971), Belgium (1987), Turkey (1994), Greece (2000), Puerto Rico (2000)	Japan (1969), Korea (1986), Chinese Taipei (1990)
2000-2006	Dominican Republic (2003), United Kingdom (2005), Mexico (2006)	India (2004), China (2006)
Future	Canada (2009), Brazil (2009-2010), Netherlands (2010)	Chile (2010), Mexico (2011), Thailand (2012), Singapore (2012)

Export	Atlantic	Hybrid (Middle East)	Pacific
1964 - 2000	Algeria (1964), Libya (1970), Trinidad (1999), Nigeria (1999)	Abu Dhabi (1977), Qatar (1997), Oman (2000)	Alaska (1969), Brunei (1972), Indonesia (1977), Malaysia (1982), Australia (1989)
2000-2006	Egypt (2005)		
Future	Equatorial Guinea (2007) , Norway (2007), Angola (2010), Russia (2012), Venezuela (2011)	Yemen (2009), Iran (2011)	Sakhalin (2008), Peru (2009), Myanmar (2013), Papua New Guinea (2013)

Source: IEA, 2007

Given the long-term nature of gas investments and capital intensive nature of the industry (due to high asset specificity), producers would be interested in protecting their interests - especially during the periods of low gas prices. It is possible that the

[28] North America includes the United States, Canada and Mexico.
[29] L'Hegaret et'al, *International Market Integration for Natural Gas: A Cointegration Analysis of Prices in Europe, North America & Japan*, 17, The Energy Journal (2003).
[30] Like regular spot LNG auctions on an electronic platform. See Frisch, M., *LNG market may soon see emergence of regular auctions for spot cargoes*, LNG Journal, April, 2008.

importance of LNG[32] would influence the rent-sharing mechanism between exporters and importers. Considering the diversity of suppliers and differences in their interests, could this lead to a group that influences the LNG market? If yes, then *how?* Could the existing suppliers desire or push for price indexation that reflects various changes in market fundamentals and trade? This is the main focus of this work.

1.2 RESEARCH PROBLEM

Market data indicates that gas prices, in liberalized markets, are more volatile than oil price.[33] A reason for this is the lack of a unified pricing structure for natural gas globally.[34] Gas price volatility could also be attributed to relaxation of take-or-pay and destination clauses; focus on short-term contracts, supply-demand mismatches, capacity constraint, and the security of supply concerns.

Vivienne Cox[35] rightly asserts that a growing number of discontinuities are obvious across the principal markets and the entire "gas industry is at cross-roads"[36]. Jensen concluded that the nature of LNG trade in the future would be determined by answering the questions: "How will prices be determined?" and "What are the new risks and rewards that flow from the de-integration of the LNG chain?"

Hallouche opines, and rightly, that "*netback pricing*[37] *is less relevant for LNG and the quest for new pricing systems for LNG will become an issue of importance"*[38]. Victor et 'al further assert that robust LNG trading requires "more standardized pricing mechanisms"[39]. Shook and Jaffe focused on "the potential for increased

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[31] Aissaoui, A., *Market risks in a changing LNG World: Exploring alternative mitigation strategies for MENA Project*. Vol. 49, No.44, MEES, 30th October 2006.
[32] Essentially, LNG market has expanded due to increased natural gas demand; security of supply concerns, as well as, climate change issues and market deregulation.
[33] Mazighi A., *Some risks related to the Short-Term Trading of Natural Gas,* Page 233, Paragraph 2, OPEC Review; September 2004.
[34] Wagbara, O., *To what extent is a liquid LNG Hub, in the Middle East, feasible?* Paper presented at the Middle East Gas Summit (MEGAS), Qatar, 2008.
[35] Vivienne Cox is the Chief Executive, Gas, Power and Renewable Energy at British Petroleum.
[36] Cox V., *Great Gas Projects need Great Gas Markets – What does the future hold?* Speech at the Gastech Conference, Bilbao, March 14, 2005.
[37] Netback Pricing is the most widely used approach for International LNG price determination in the Atlantic Basin.
[38] Hallouche, H., *The Gas Exporting Countries Forum: Is it really a Gas OPEC in the making?* NG 13, OIES, June 2006
[39] Victor, D.G; et'al, Natural Gas and Geopolitics: From 1970 to 2040, P.14, (2006).

standardization, commoditization and globalization" of LNG trade. Their brief discussion of pricing in Atlantic Basin LNG trade, however, predicts increased flexibility and market linked pricing.[40] Focusing on the Pacific Basin, Miyamoto and Ishiguro questioned the rationale behind the continued pricing of LNG imports based on the JCC.[41] They described the current pricing regime as irrational and suggested a transition to netback market value based on competing fuels.[42]

These opinions clearly provoke other questions that are fundamental to resource rent and market determination. Although today's gas pricing situation is unfavorable to both producers and consumers, some producers contend that it provides unfair revenue from their gas. Perhaps, the latter argument offers justification for taking action to unify and stabilize gas prices. This assertion is reinforced by the common desire of producer-groups to maintain a minimum price level above which prices are allowed to fluctuate.[43] The foregoing portends market influence through price-fixing or volume control.

One means by which gas exporters could exert influence on the gas markets is through LNG. Specifically, by applying a model contract pricing system, exporters may be able to unify LNG pricing, upstream in the regional markets. This book posits that a group of LNG exporting countries could begin to fix LNG contract prices by using a preferred reference price (Henry Hub) as basis for indexation or uniformly adopting a minimum absolute price level ($x). Such a cartel could establish the price, while consumers determine quantity through the market. It could reasonably determine a high revenue-generating price/volume using a reliable demand-supply model. Alternatively, exporters could opt to defend a price band through quantity control depending on the existing market (demand) scenario.

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[40] Shook, B. and Jaffe, A.M., *Developments in Atlantic Basin LNG: Implications for Japan*, Working Paper
[41] Miyamoto, A., and Ishiguro, C., *A new paradigm for Natural Gas pricing in Asia: A perspective on Market Value*, NG 28, OIES, February 2009.
[42] They argue that the netback market value (NMV) approach is: more rational; beneficial for the expansion of gas markets; necessary to achieve price differentiation due to the varying energy usage in each country. Apparently, NMV is effective ***only to the extent*** that the price(s) of competing fuel(s) is competitively determined. In other words, because LNG has become a global commodity, it is irrational to determine LNG netbacks (prices) on the basis of non-transparent prices (or prices that are not as transparently determined as crude oil prices).
[43] Alhajji A.F. and Huettner D. *OPEC and other Commodity cartels: a comparison.* Page 1155, Paragraph 2, 28 Energy Policy, (2000)

A similar effect is achievable by controlling the quantity, but at present exporters lack spare liquefaction capacity. In a low price situation, LNG supply quotas may be issued in proportion to existing contracts, liquefaction capacity, as well as, gas reserves. Quantitative ceilings may be placed on exports also. The initiation of liquefaction projects with un-contracted capacity is evidence that this is an option. Although creating spare capacity seems uneconomical, it is possible since over 20% of global liquefaction capacity remains uncontracted. Another option could be to determine supply route(s) and/or the volume that goes to a particular destination. This may be achieved by allocating markets to particular exporters on a long-term basis. Given the above alternatives, there then arises the question of feasibility.

Does the economics of LNG permit price-setting by exporting countries? Given their potential leverage, could LNG exporters collude to influence trade by altering price determination patterns in the Atlantic Market? Could they uniformly adopt a new LNG pricing regime? How would a uniform price regime operate in a fragmented global market where competing fuels exist and market dynamics differ? What could be the implications for LNG trade if such a uniform pricing mechanism is developed?

Meanwhile, the following would have to be determined: the vital but uncertain role of a price leader; key members of the group; and the most feasible option. This book seeks to answer some of the above questions in addition to other objectives spelt out below.

1.3 PURPOSE OF THE STUDY

Starting from the premise of a hypothetical LNG exporters' organization the author *assumes* that LNG trade could be influenced. This assumption is based on arguments and postulations in the existing literature. For instance, Bobrow and Kudrle opined that cartels "are mostly feasible where they are least needed - where there are few sellers with high concentration".[44] Meanwhile, Desta discussed the legal premise of natural resources cartels within WTO rules.[45] In this regard, Yergin

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[44] Bobrow, D.B. and Kudrle, R.T., *Theory, Policy, and Resource Cartels,* pp. 3-56, Vol. 20, No. 1, The Journal of Conflict Resolution, March 1976.
[45] Desta, M. G., *OPEC, the WTO, Regionalism and Unilateralism,* in 3, Journal of World Trade, Vol. 37, (2003)

asserts that “an association of LNG exporters is likely and, indeed, already in the making”[46].

Principally, the book is concerned with the potential for an organization of LNG exporters - Organization of Atlantic LNG Exporting Countries (OALEC)[47] - to develop and impose a price concept[48]or control export volumes in Atlantic LNG trade. The work considers the hypothetical case of an LNG Export Organization developing a mechanism[49] to influence LNG prices. The book examines the feasibility or otherwise of a Uniform LNG Pricing Scheme or Volume Control; and analyzes the consequences of such a development on LNG trade.

In this regard, specifically:

- the suggestion that gas exporting organisation, such as the GECF, might take such action is hypothetical (rather than actual);
- the price mechanism that the organisation might develop and implement has been devised by this author (and not based on any actual proposal).

1.4 RELEVANCE OF THE STUDY

The study is relevant since the success of climate change policies will be significantly affected by the extent to which gas markets become integrated. Besides, the strategic nature of gas raises issues of redistribution of leverage in the global political economy from energy importers to exporters (either acting alone or in a group). Understanding the practical application of a uniform pricing formula would, therefore, enable energy analysts to appreciate and predict any cartel behaviour accurately. The primary research question and the outcome of this work, however, are not dependent on whether the Forum persists and successfully develops/implements any price influencing scheme.

Furthermore, the book is a pertinent investigation resulting from the gas cartel question as LNG becomes increasingly accepted amid the greater risk of market

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[46] Kalicki, J. and Goldwyn, D. (Eds.) Energy and Security: Toward a new Foreign Policy Strategy, 2005

[47] For the purpose of this Book, the organization would include exporting countries that are major players in the Atlantic Basin – Algeria, Egypt, Libya, Nigeria, Qatar, as well as, Trinidad and Tobago.

[48] The Pricing concept is proposed in Chapter Three and applied in Chapter Four.

[49] Either a price or volume influence mechanism but with the ultimate aim of keeping Price(s) higher than it would have been.

manipulation. Previously, the prices of gas gave a wrong indication of its value,[50] but now demand is becoming fairly price inelastic, as consumers are ready to pay for its energy content and added characteristics. Therefore, it is a relevant study of LNG cartels and pricing systems which remains under researched[51] relative to many studies that focus on LNG technologies and their possible consequences[52]. Focusing on the developments in the fast growing LNG market, the study is pertinent as resource assertiveness gradually spreads among petroleum-rich countries. It is a pre-emptive effort to determine the possible LNG pricing approach adoptable by exporters or group of exporters. This book can be appreciated more in terms of its future relevance.

1.5 METHODOLOGY, SCOPE AND STRUCTURE

According to Bobrow and Kudrle,[53] no single perspective[54] comprehensively covers the relevant issues of an intergovernmental resource cartel. The Research Methodology, therefore, is a combination of quantitative and descriptive methods based on the theories of cartels, exhaustible resources and collective action. The following sub-sections describe the approach, structure and scope of the book.

1.5.1 Approach

To set the stage for the quantitative approach, a description of Atlantic Basin LNG trade is undertaken. In the same vein, theories of exhaustible resources, substitution and cost are applied to evaluate the principles of pricing in international gas trade as background for proposing a uniform pricing regime[55].

Subsequently, in a quantitative approach, a uniform price formula[56] and a volume control mechanism are generated, simulated and iterated in a Spreadsheet Model

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[50] Banks, F. E; *A perspective on natural gas*, in Paragraph 2, on Page 16, November/December OPEC Bulletin, 2003.
[51] A clear indication of this fact is provided through the Literature Review below.
[52] Victor, D.G; et'al, Natural Gas and Geopolitics: From 1970 to 2040. Page 15, (2006)
[53] Bobrow, D.B. and Kudrle, R.T., *Theory, Policy, and Resource Cartels,* pp. 3-56, Vol. 20, No. 1, The Journal of Conflict Resolution, March 1976.
[54] The five basic perspectives for the analysis of resource cartels which they considered are: the theory of cartels; the theory of depletable resources; coalition theory; internal politics approach and the theory of collective action.
[55] This consists of proposed pricing concepts that could be adopted by an organisation of LNG exporting countries.
[56] The Formula is derived from the proposed pricing concepts and is designed to suit the book.

of LNG trade. The hypothesis is that *uniform LNG pricing is feasible and its adoption offers sufficient benefits*[57] *vis-à-vis trade-offs*. Using the model, a probabilistic analysis of different market scenarios, vis-à-vis new prices, is undertaken. The outcome reveals the effects of exogenous price/volume shocks under different LNG and pipeline gas market scenarios.

Finally, given the hypothesis, feasibility is evaluated based on the following analytical criteria[58], from a country-specific perspective:

- **Extra rent earned**

For each exporter, the extra rent (price differential to marginal costs[59]) accruable is directly related to the new price, HHI and inversely proportional to the price elasticity of demand. Derived from Nash and Cournot[60] $\therefore (Price - MC) = (Price) \times \left(\frac{HHI}{\in} \right)$;

Where:

MC = Marginal Cost;

Hirschmann-Herfindahl Index (HHI) = ΣM_s^2; M_s^2 = Square of market share (M_s) and;

ε = Price elasticity of demand.

- **In terms of revenue, market share and price differential**, is each country better-off or worse-off given its:
  - Existing and potential liquefaction capacity
  - Dependence on export revenue or Discount rate[61]
  - Current and forecasted demand levels

- **Resource abundance**: Each exporter's willingness to adopt an influence mechanism is directly related to its resource abundance (as liquefaction capacity changes over time).[62]
- **Diversified pricing *versus* uniform pricing/volume control**
- **Price Leader or Swing Producer**

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[57] This includes a combination of Revenue, Market Share and Negotiating Leverage (applied in Chapter Five).

[58] Justified, described and applied in Chapter Five on the basis of an extensive literature review undertaken therein.

[59] In addition to the differential rent, part of the consumer surplus also goes to the Exporter due to the collusive action and the inherent capacity constraint in most energy markets.

[60] J. Nash, *Non-cooperative Games*, 286-295 Annals of Mathematics, Vol. 54, no. 2 (September 1951).

[61] Discount rate, here, defines a country's willingness to forego present gains for higher prices in the future.

1.5.2 Structure of the Book

Following from the above methodology, each chapter of the Book addresses one or more sub-research questions linked to the primary research question - ***To what extent could an LNG export organization, operating a uniform pricing or volume control mechanism, influence LNG trade in the Atlantic Basin?*** A brief description of the chapters, undertaken below, reveals how the secondary research questions are addressed.

Given the research question, it would be inconsistent to analyze the impact of an exogenous factor (Cartel) on LNG trade without establishing the present and potential trade patterns in the region. Chapter Two, therefore, describes each exporting country that is likely[63] to participate in an organisation of LNG exporting countries. It answers the question "w*hich could be the key countries in any such cartel and why?"* by describing each country's LNG trade flows; supply capacity and future investment scenario.[64]

The research theme underscores the need to examine and understand how price determination occurs within the Atlantic Basin LNG market - how efficient and competitive are the current pricing regimes? Accordingly, Chapter Three traces the evolution of pricing concepts that underlie international gas trade by reviewing literature on price determination. This section of the Book rigorously documents the development and current situation of three main price mechanisms:

- Hub based spot pricing: NBP and Henry Hub
- Oil product indexed netback market pricing in Continental Europe pipeline trade
- Crude oil linked (JCC) pricing for LNG in the Pacific Basin

Furthermore, it relies on price fundamentals to suggest possible uniform pricing concepts for Atlantic Basin LNG exporters. In other words, it answers the question: *what principle would underpin a uniform pricing mechanism for LNG in the Atlantic*

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[62] Conversely, a relatively new LNG exporter with small reserves would be either cautious or indifferent about an influence mechanism.
[63] The countries were chosen based on their participation or ability to participate (liquefaction capacity and market share) in the Atlantic Basin LNG market within the research's time frame - between 2005 and 2013.
[64] It highlights the demand situation in some the regional market but focuses more on supply-side issues.

Market? As stated in section 1.6.1, Chapters Two and Three jointly define the research context.

Chapter Four is the Atlantic Basin LNG Trade Model (ABLTM). It describes the data set and analyzes the result. Atlantic Basin LNG Trade Model (ABLTM) is representative of a month-scale LNG market involving six exporting countries and five importing countries.[65] The total revenue function is the optimization function and it is subject to some constraints – liquefaction capacity, price (given), and gas reserves.[66] The Chapter answers the secondary research questions: "*In what market scenario is uniform pricing or volume control applicable?"* and "*would a uniform pricing regime be easier to implement than volume control?"* An attempt is also made, in the chapter, to show the conceivable benefits or losses to exporters from uniform pricing or volume control?

Having applied the new price regime in the LNG trade model, Chapter Five addresses the feasibility issue by relating the simulation result to each country's LNG context. It entails a study of cartel literature - in particular how price or volume quotas are manipulated over time. Considering the nature of gas markets and classic cartel problems it answers the following secondary questions:

- What conceivable permutations of uniform pricing (UP) and/or volume control (VC) are realistic?
- What are the key considerations for adopting uniform pricing or volume control?
- What are the implications of uniform pricing or volume control for each exporter?

Chapter Six speculates on the potential implications, of uniform pricing, for LNG trade (project finance, contracting, price arbitrage and demand). It first discusses recent empirical developments in the global LNG market (as they relate to this work). The concluding section then reflects on the contrast between what the model suggests and empirical developments.

[65] The exporting countries are Algeria, Egypt, Libya, Nigeria, Qatar, as well as, Trinidad and Tobago, while the importing countries are France; Italy; Spain; the U.S and UK.

1.5.3 Scope of Research and Definition of Terms

A key significance of LNG is the prospect for more arbitrage and connectivity of diverse markets in addition to the volumes traded. LNG trade offers a range of options to gas exporters and importers – it continues to integrate regional gas markets in the Atlantic Basin. The book focuses on the Atlantic Basin LNG market for the following reasons.

First, the two largest natural gas markets in the globe are located in the Atlantic Basin – in North America and Europe. Furthermore, Europe has the highest regional dependence on LNG and demand is expected to increase even more.[67] Second, the region has the most competitive natural gas markets in the US and UK. Given the degree of liquidity in these markets, LNG transactions are more flexible in the Atlantic Basin due to the number of aggregators with import capacity and uncommitted vessels.

Moreover, this situation has resulted in a high number of LNG arbitrage in the region and the trend is expected to continue. Such expectation - another reason for focusing on the Atlantic Basin - is traceable to the fact that exporters in the region are the most diversified. In other words, Atlantic Basin LNG exporters supply markets globally (unlike Asia-pacific exporters that do not export to the Atlantic). The reason is because Atlantic exporters have a lot of uncontracted capacity. As such, the irreversible trend towards globalization of gas trade, through LNG[68], lies in the Atlantic Basin.

Atlantic Basin LNG market is, therefore, the research scope and the time frame is between 2005 and 2013. This covers LNG trade on either side of or across the Atlantic Basin (shown on Table 1.3 on the next page) - North America (mainly the US); Trinidad and Tobago; Spain; Italy; France; United Kingdom; Algeria, Egypt; Nigeria; Libya and Qatar. In addition to the reasons offered, these countries were chosen[69] from the Atlantic Basin for manageability and detailed analysis.

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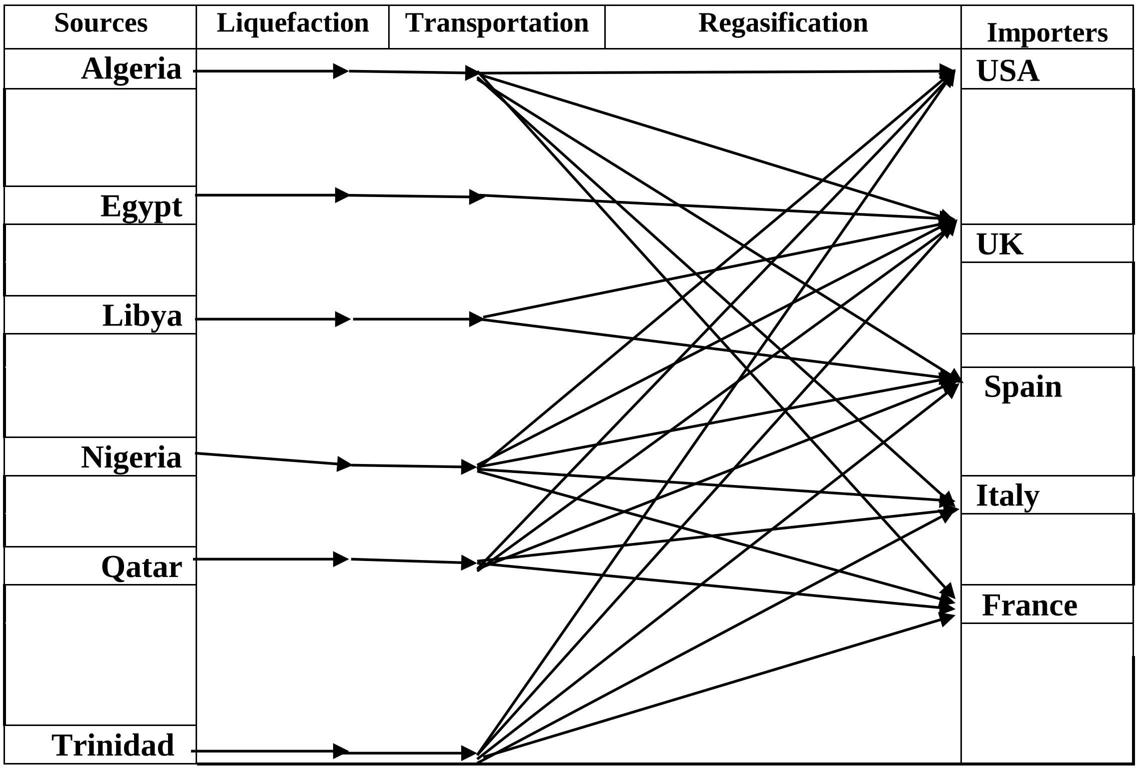
[66] Transportation cost is assumed fixed by the acquisition of vessels or exogenously determined.
[67] The potential demand for LNG in the importing markets is extensively described in Chapter Two. The discourse also justifies the countries chosen for this exercise.
[68] IEA, Natural Gas Review 2008, (Paris: OECD/IEA, 2008).
[69] The criteria and process of selecting the countries is described in Chapter Two.

Table 1.3 Research Scope



Considering that large amounts, in the global gas industry, have been committed to LNG, the simulation exercise is focused on the supply-side of the LNG value chain. For a comprehensive interpretation of results, demand-side issues are also taken into consideration in subsequent analysis. Although the book dwells on LNG Trade in the Atlantic Basin, empirical observations from Asia Pacific markets are also captured in Chapter Six.[70]

Definition of Terms and Concepts

Feasibility, here, simply means that it is practical to increase exporters' revenue at a determined price payable by importing countries' consumers. An extensive discourse on '*what is economically feasible?*' is avoided here - it becomes more complicated to explain what economic feasibility is when the expected benefits are long term in nature.

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[70] In an attempt to reconcile the principles of uniform pricing and volume control with globalizing LNG trade.

Uniform LNG Pricing[71] implies an agreement about LNG export price or pricing structure by a group of LNG Exporting Countries, applicable to their customers globally. It could be conceived as a system in which each and every exporter applies the same principle/formula to determine the delivered price payable by all buyers (in the long term LNG sales contracts).

Volume Control could be conceived as any form of export control -by issuing quotas or market sharing or supply manipulation through delay/cancellation of future projects - to influence the market. However, Volume Control Mechanism as simulated here, is solely cut in current LNG production – to constrain the Average Contracted Volume. Uniform Pricing and Volume control mechanisms are assumed to be different sides of the same coin. And the ultimate aim is *keeping price higher than it would have been*.

1.5.4 Originality and Justification for Methodology

The methodology and structure of the book follows from the nature and infancy of LNG trade. **This effort differs from the others because** it appreciates that LNG exporters may not collude globally but could operate through direct uniform pricing or supply manipulation regionally. It, therefore, emphasizes price-fixing on a regional scope because LNG prices vary regionally (but are defined and influenced by various exogenous/inter-regional factors). The author captures the uniqueness of LNG trade, pricing and regional markets.

This approach has been chosen because other studies on international cartels have either been comparative or applied actual production quotas.[72] Moreover, the theoretical perspective applied here has its implications for the questions asked – as suggested by Bobrow and Kudrle.[73] For instance, Coccorese confirmed that through informal sharing of information companies could influence the market and reap monopoly profit.[74] Alhajji and Huettner compared the cartelization of some

[71] This is the applicable definition here. Other conceptual and theoretical definitions of Uniform Pricing have been provided in the Analytical Framework below.
[72] In cases when the **subject** of the research is a supply-restricting cartel like OPEC.
[73] Bobrow, D.B. and Kudrle, R.T., *Theory, Policy, and Resource Cartels,* pp. 3-56, Vol. 20, No. 1, The Journal of Conflict Resolution, March 1976.
[74] Coccorese, P., *Information Exchange as a Means of Collusion: The Case of the Italian Car Insurance Market*. Journal of Industry, Competition and Trade, November 2008.

globally-traded commodities (like cocoa, tin, tobacco, copper, steel and diamond) with crude oil (OPEC).[75] Meanwhile, Elaine has shown the significance of market structure to the effectiveness and sustainability of a cartel.[76]

It is important to emphasize, therefore, that LNG is a different commodity – with a unique pricing and trading regime.[77] The non-existence of an operational LNG cartel with production quotas for its member-countries and differences in market structures makes an absolute comparative analysis unsuitable for this effort. However, the efforts of Eckbo, Alhajji and Huettner; as well as, Bobrow and Kudrle revealed different reasons why some cartels were more successful than others. As such, further review of cartel literature was undertaken,[78] in Chapter Five, to construct an analytical framework for contextualizing the simulation results.

The book uniquely adopts probabilistic analysis in a spreadsheet model as a solution mechanism and descriptively analyzes the effect of market control mechanisms on LNG trade. The inherent benefit maximization objective of gas-rich countries justifies the modeling assumptions which are hinged on economic theories. LNG producers strive to optimize production to ensure the efficient utilization of reserves and liquefaction capacity. Herein is the justification for a probabilistic analysis. Besides, there is no research on the application of uniform

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[75] Alhajji A.F. and Huettner D. *OPEC and other Commodity cartels: a comparison*, 28 Energy Policy (2000).

[76] Tan, E.S., *Market structure and the coal cartel in early nineteenth-century England*, Vol.62, Issue 2, Economic History Review, 2009.

[77] The peculiarities of LNG trade and its pricing regimes are extensively discussed in section 2.1.2 and Chapter Three respectively.

[78] Some of the literature reviewed in Chapter Five includes: Eckbo, P., *OPEC and the Experience of some non-petroleum international cartels*, MIT Energy Lab working paper, June 1975; Pindyck, R., *The cartelization of world commodity markets*, in Vol. 69, No. 2, The American Economic Review, May 1979; Alhajji, A. and Huettner, D., *OPEC and other commodity cartels: a comparison*, in Vol. 28, Energy Policy, 2000; Mikdashi, Z. *Collusion could work*, No. 14, Foreign Policy, spring, 1974; Bergsten, C., *The threat is real*, No. 14, Foreign Policy, spring, 1974; Fog, B., *How are Cartel prices determined?* Vol. 5, Journal of Industrial Economics, November 1976; Hnyilicza, E., and Pindyck, R., *Pricing policies for a Two-Part Exhaustible Resource Cartel: The Case of OPEC,* Volume 8, European Economic Review, August, 1976; Osborne, D., *Cartel Problems*, in Vol. 66, No. 5, The American Economic Review, December, 1976; Mills, D. and Elzinga, K., *Cartel Problems: Comment*, in Vol. 68 No. 5, The American Economic Review, December, 1978; Stevens, P., *National oil companies and international oil companies in the Middle East: Under the shadow of government and the resource nationalism cycle*, Vol. 1, No. 1, Journal of World energy Law and Business, 2008; Adelman, M., *The real oil problem*, in Regulation, spring 2004; Adelman, M, and Lynch, M; *Markets for Petroleum*, Encyclopedia of Energy, Volume 3, 2004; Claes, D., The Politics of Oil-Producer Cooperation, 2001; Alhajji, A. and Huettner, D., *OPEC and other commodity cartels: a comparison*, in Vol. 28, Energy Policy, 2000; Danielsen, A.L. The Evolution of OPEC, (1982); and Griffin J.M. & Teece D.J (Eds), *Introduction* in OPEC Behaviour and World Oil Prices, 1982

pricing in international gas trade. This effort is, therefore, an attempt to see how the principles of uniform pricing could be applied in LNG trade.

1.6 LITERATURE REVIEW

Against the above introduction, it is important to show the existing body of knowledge into which this book fits and builds on. Several years ago, Banks highlighted the poor treatment given to natural gas in the economics literature.[79] But today a lot has been done and the following is a review of literature on International gas trade; gas pricing; producer cooperation and the theoretical basis of uniform pricing.

Mazighi examined the historical trend of international gas trade and showed the firm correlation between both forms of gas (pipeline and LNG). He stated that "before LNG becomes predominant, we need a delinking of these two means of trading gas".[80] Applying a schematic diagram in the analysis, Mazighi concluded that there was no evidence to support the emergence of a global LNG market before 2010. He also predicted a bipolarized international gas market in the Pacific and Atlantic Basins. The latter prediction has materialized but not in the manner suggested. Meanwhile, he did not specify whether gas and oil markets should be delinked in pricing or trading terms. Furthermore, one would argue that, contrary to Mazighi's thinking, the correlated and supplementary nature of LNG to pipeline gas enhances the globalization of gas trade.

Brito and Hartley may have towed the above line of thought when they emphasized the importance of expectations in determining market outcomes and enhancing the transition to a world gas market. They claimed that "endogenous (induced) changes in expectations about market structure can reinforce and amplify the effects of the changes in exogenous factors"[81]. In their conclusion, among other factors, "an increasing role for spot markets in the trading natural gas"[82] was suggested as potential replacement for long term contracts. While the US and UK gas markets

[79] Banks, F., *An Introduction to the Economics of Natural Gas*, p.27, Vol. XXVII, No.1, OPEC Review, March 2003.
[80] Mazighi, A., *An Examination of the international natural gas trade*, Vol. 24, Issue 4, OPEC Review, 2003.
[81] Brito, D., and Hartley, P., *Expectations and the Evolving World Gas Market*, Vol. 28, No.1, Energy Journal, 2007
[82] *Ibid.*

have greatly influenced gas trade, one can not foresee spot trading replacing long term LNG contracts in the medium term.[83] Dwindling domestic supply in both countries may have provoked increased gas trade in the Atlantic Basin but also different pricing issues.

Amidst gas supply disputes and transit issues,[84] Stern considered the new security environment for European gas and competition for LNG supplies.[85] He traced the less favourable relationships between importers and governments of major gas trading countries. In the short term, according to him, steps should be taken to protect end-users from risks relating to infrastructure failure and inadequate storage. But in the long term, the combined effects of depleting domestic reserves, geopolitical tensions[86] and globalizing LNG trade would determine European gas supply.[87]

Meanwhile, Nyssens and Osborne considered the potential effects of more sophisticated profit splitting mechanisms (PSMs) on the European gas market. They concluded that PSMs were a disincentive to arbitrage[88] and infringe anti-trust law. They, noted that in some cases PSMs are not restrictive and suggested further “detailed analysis of contractual mechanisms and their economic context”.[89]

Drury, subsequently, analyzed the EC’s agreement with Algeria on the issue. He appreciates the commission’s dislike for PSMs on the logic that “*it is trying to build a single European gas market, and anything which restricts the buyer’s choice of*

[83] Wagbara, O., *To what extent is a liquid LNG Hub, in the Middle East, feasible?* International Energy Law Review, Issue 3, 2008.

[84] There have been several price and contractual disputes between gas exporters and importers, as well as, transit disputes. For more details of these, please see Pirani, S. (Ed.), Russian and CIS Gas Markets and their impact on Europe, 2009 and Pirani, S. et’al, *The Russo-Ukrainian gas dispute of January 2009: a comprehensive assessment*, February, 2009 at http://www.oxfordenergy.org/pdfs/NG27.pdf ; Forbes, A., *Gassi Touil: A failed partnership*, in Issue 14, LNG Focus, October 2007; and Nyssens, H. et’al, *The territorial restrictions case in the gas sector: a state of play*, Competition Policy Newsletter, 1/2004

[85] Stern, J., *The new security environment for European gas: worsening geopolitics and increasing global competition for LNG*, NG 15, Oxford Institute for Energy Studies, October 2006

[86] Between Russia and FSU countries on the one hand, and on the other hand, between EU countries and CIS, as well as, Middle East countries.

[87] Stern, J., *The new security environment for European gas: worsening geopolitics and increasing global competition for LNG*, NG 15, Oxford Institute for Energy Studies, October 2006.

[88] This is especially the case when the LNG is sold Free on Board (FOB).

[89] Nyssens, H., and Osborne, I., *Profit splitting mechanisms in the liberalised gas market: the devil lies in the detail*, in Competition Policy Newsletter, No.1, Spring 2005

where in Europe to resell the gas it has bought is essentially a barrier to cross-border trade and anti-competitive".[90] Drury also highlighted potential legal disadvantages of the agreement it would create difficulties for other LNG (FOB) exporters and may also push them back to delivered sales.

It is notable that, in the current LNG market, European LNG importers are not particularly keen to resell acquired LNG *in Europe*[91] but rather have an international perspective. While concluding a preview of LNG trade, Weitfeld and Fenzl echoed the above view that "*international players will have a distinct advantage over regional actors since global players are obviously better poised to meet producer expectations with regard to serving different markets*".[92]

Moreover, Luciani argues that the EC has not succeeded in creating an integrated gas market "and in all probability never will".[93] This view is similar to an earlier result obtained by Franziska, Hirschhausen and Kemfert. They suggested that Cournot competition is the most practical representation of the European gas sector but observed that it leaves room for imperfect competition to the advantage of *"de-facto national monopolies".*[94] In addition to the works reviewed here, Robinson[95]; Neumann et al[96]; and Asche et'al[97] concluded that some national markets within Europe are integrated.

Perhaps, given Luciani's assertion, as well as, other modeling results above, it is conclusive that actual market integration[98] is different from price convergence or co-movement. While the theoretical basis for building an integrated EU-wide gas market to attract exporters is economically sound, it would be important to

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[90] Drury, D., *Destination restrictions: Algerian agreement with EC creates potential headaches for Atlantic Basin FOB suppliers*, Issue 14, LNG Focus; October, 2007.
[91] As the European Commission anticipates or expects them to.
[92] Wietfeld, A, and Fenzl, N., *LNG Trading: Overview and Challenges*. OEF, February 2009.
[93] Luciani, G., *The Gas supply security Issue*, OEF, February 2009.
[94] Holz, F., et al., *A Strategic Model of European Gas Supply (GASMOD)*, Vol. 30, No. 3, pp. 766-788, Energy Economics, 2007
[95] Robinson, T., *Have European gas prices converged?* Vol. 35, Issue 4, Energy Policy, April 2007.
[96] Neumann, A., et'al., *Convergence of European Spot Market Prices for Natural Gas? A Real-Time Analysis of Market Integration*, Presentation at the 7th IAEE European Energy Conference, Bergen, August 2005
[97] Asche, F., et'al, *European market integration for gas? Volume flexibility and political risk*, Vol. 24, Energy Economics, 2002
[98] "Market Integration" is the interaction of markets and prices across national boundaries (both physically and financially).

reconsider the strategic role of IOGCs for the EC's to achieve its goal. Meanwhile, to what extent would exporters be willing to bear the underlying risks associated with selling in such "liquid" or "integrated" market?

Taking a different turn, Foss considered the likely trend of US natural gas supply and prices, as well as, the future role of LNG imports in North America. She also questioned the extent to which de-linked oil and gas prices could affect fuel usage and competition in the long-run. A relevant fact deductable from the study is that "*the impact of LNG will hinge on US market conditions, intra-basin competition for cargoes, and the commercial strategies of LNG operators*".[99] While, shale gas production has affected US offering price for LNG, it would be interesting to know what exporters could do in terms of new investments.

Due to the growth in gas trading Mazighi investigated the efficiency of futures markets[100] and risks associated with short term trading of natural gas[101]. The former research showed that more liquidity is needed with relative increase in spot gas transactions for the futures market to be efficient. And in the latter article, Mazighi argued that "short-term trading of gas is far from riskless".[102] In other words, volume, price and infrastructure risks, associated with short term trading, present producers, consumers and project financiers with varying challenges.

Like Mazighi, Brown and Yucel undertook a study on the determinants of natural gas prices in the US.[103] Sequel to that, they investigated the co-movement of gas prices in North America and Europe. Applying econometric tests, they considered whether such price co-movements were arbitrage driven or vectored through oil prices. Their bivariate tests reveal that coordinated gas price movements across the Atlantic could be due to LNG arbitrage and that regional gas prices also adjust to deviations in the long-run crude oil-gas price relationship.[104]

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[99] Foss, M., *United States natural Gas prices to 2015*, NG 18, OIES; February, 2007.
[100] Mazighi, A., *The efficiency of natural gas futures markets*, in OPEC Review, June 2003.
[101] Mazighi A., *Some risks related to the Short-Term Trading of Natural Gas,* Page 233, Paragraph 2, OPEC Review; September 2004.
[102] *Ibid*.
[103] Brown, S. and Yucel, M., *What drives natural gas prices?* The Energy Journal, Vol. 29, No.2, 2008.

In a similar effort, Neumann showed that, through price convergence, Atlantic Basin gas markets were integrating.[105] Neumann applied the Kalman Filter method and the exercise indicated spot natural gas prices in regional markets are converging towards the law of one price.[106] The effort also highlighted the role of LNG – especially short-term trading - in the Atlantic Basin. The research calls for more study on how the restructuring of Europe's gas market would affect liquidity and further convergence in the Basin. In this vein, Rice University's World Gas Trade Model indicates that Russia would play a pivotal role by linking LNG prices between North America and Europe when it enters LNG trade.[107]

Meanwhile, Mazighi assessed the potentials of either the Henry Hub (HH) or NBP price becoming the natural gas marker. He posited three conditions for the emergence of an international reference price[108] and concludes that "*the HH price has a bigger potential than the NBP to become an international price reference, particularly because the UK market is supposed to import more and more gas indexed to oil in the coming years*".[109] However, Mazighi did not foreclose the probable existence of two or more regional reference prices for gas. Perhaps, it would be interesting to reconcile the results obtained by Neumann; Brown and Yucel with Mazighi's.

Focusing on China, Miyamoto and Ishiguro traced the penetration of LNG into the Chinese energy mix. Their study[110] also expounded on gas price determination and the reasons behind China's shift in LNG import policy. According to the authors, government scaled down import plans due to LNG's inability to compete in China's energy markets.[111] In their view, LNG imports are considered expensive in China and so it faces a bleak future in the medium term. A major setback of their work,

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[104] Brown, S. and Yucel, M., *Market Arbitrage: European and North American Natural Gas Prices*, Vol. 30 Special Issue, Energy Journal, 2009.
[105] Neumann, A., *Linking Natural Gas Markets – Is LNG doing its job?* Vol. 30, Special Issue, Energy Journal, 2009
[106] With differences due to transportation or transaction cost.
[107] Rice University, *Impacts of Worldwide shift to greater reliance on Natural Gas analyzed*, News Release
[108] The three conditions are an organized market, sufficient level of liquidity in the market and the existence of a global market (for gas).
[109] Mazighi, A., *Henry Hub and national balancing point prices: what will be the international gas price reference?* OPEC Review, September 2005.
[110] Miyamoto, A., and Ishiguro, C., *Pricing and Demand for LNG in China: Consistency between LNG and Pipeline Gas in a fast growing market*, NG 9, OIES, January 2006

however, is that the potential effects of on-going climate change initiatives and environmental concerns about GHG from coal were ignored.[112]

Roberts reiterated some of the concerns highlighted by Miyamoto and Ishiguro, but concludes differently. According to him, "China's nascent relationship with LNG…is bisected by the intervention of internal and international market forces, and these are forces which clearly have the capacity to shape the prospects for the growth of LNG in China".[113] Going by the change in Gas Utilization Policy and energy prices[114], however, regional initiatives may be favourable to LNG imports and Fesharaki posits that "different provinces and sectors (China) will be subject to different pricing"[115].

Apparently, as Yergin and Stoppard predict, enhanced LNG trade could have "far-reaching impact on the world economy, bringing new opportunities and risks; new interdependencies and geopolitical alignments".[116] Huntington similarly highlights the significance of growing inter-regional and dynamic interrelationships within the gas industry and advises policy-makers and analysts not to ignore the trend.[117]

Adopting a mathematical model of global energy markets[118], Aune et'al presume that lower costs would enhance LNG's incursion into Atlantic gas markets. They focused on prices and different trade scenarios of global gas market in the future.[119] A major outcome of their work is the vital role which Middle East gas supplies could play in restraining upward price movements (if investments are unconstrained by political factors). However, expanding gas trade is not compatible with decreasing

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[111] As a result of increased LNG trade and global competition for the commodity
[112] When these factors are considered it becomes apparent that LNG's penetration into China's energy spectrum is somewhat beyond China's control.
[113] Roberts, P., *China and the LNG Revolution*, Issue 4, I.E.L.T.R, 2006.
[114] On 20th June 2008, Chinese government increased the prices of energy products by 17-18%. By 1st July 2008, wholesale electricity tariffs were allowed a 5% increase (to accommodate hikes in Coal and LNG prices). Andrews-Speed, P., *China's recent energy price rises: why now and what next?* CEPMLP Gateway, July 2008 at http://www.dundee.ac.uk/cepmlp/gateway/index.php?news=29314
[115] Fesharaki, F., *Globalization of LNG Markets: East versus West Prices and Flows*, Presentation at the 2nd IAEE Asian Conference, Perth Australia; November, 2008.
[116] Yergin, D. and Stoppard, M; *The Next Prize,* 103 Foreign Affairs Journal 82 (2003)
[117] Huntington, H., *Natural Gas across Country Borders: An Introduction and Overview*, Vol. 30 Special Issue, Energy Journal, 2009.
[118] The model combined Electricity, Coal, Crude Oil and Gas markets.
[119] Aune, F., et'al, G*lobalisation of Natural Gas Markets – Effects on Prices and Trade Patterns,* Vol. 30 Special Issue, Energy Journal, 2009.

LNG costs. This is because EPC costs are mainly determined by available expertise and equipment, relative to demand. So, as the market expands, increased investments constrain resources and hike EPC costs along the chain.

Meanwhile, fears persist of an exporters' cartel emerging from the recently formed Gas Exporting Countries' Forum. In his article, Chabrelie relies on corporate strategies to analyze the issue. She concludes that "the increasingly tangled inter-relationships and mutual holdings of the players all along the gas chain will mitigate the risk of actor impinging on prices and production capacity"[120]. Jensen posits that due to "the differences between the two markets (oil and gas)…this concept (cartelization) is unrealistic".[121] Jensen identified the prior need for a buyer and the long-term nature of gas transactions[122] as fundamental constraints to any sort of producer co-operation. But, to what extent could spot trade, contract flexibility and arbitrage increase exporters' leverage and alter the above assertion.

However, in projecting the outlook for global LNG trade (low case scenario), Jensen acknowledges that geopolitical issues could constrain supply. Two of the major findings in the work are notable: "*there are very great uncertainties about how LNG markets would develop and the likelihood of geopolitical constraints would be after 2010 when the current projects have been completed*".[123] One would argue that with demand insecurity, some proposed and on-going projects may be delayed longer. Reviewing some other literature on gas demand, contracting and pricing,[124] Jensen poses a vital question "How do you place a value on long term gas supply?" He then asserts that "It is a question that is important in making major gas project

[120] Chabrelie, M., *LNG: A Commodity in the Making*, PANORAMA 2006 at http://www.ifp.fr/IFP/en/events/panorama/IFP-Panorama06_10-GNL-VA.pdf
[121] Jensen, J.T, *The LNG Revolution*, in 24, No.2 J. of IAEE Paragraph 3, Page 34, 2003
[122] Jensen, J.T., The development of a global LNG market, (Oxford: O.I.E.S., 2004).
[123] Jensen Associates (JAI); *The Outlook for global trade in liquefied natural gas projections to the year 2020*, Consultant Report prepared for California Energy Commission in 2007.
[124] The article – *Gas as a Transitional Fuel* - reviewed by Prof James Jensen was published in the February 2008 edition of the Oxford Energy Forum. Five authors considered different aspects of the theme: Stern, J. asked whether *the future for international gas trade is constrained;* Stoppard, M., *looked at LNG growth to 2010*; Gergmann, B., assessed *European gas markets and the interplay of competition, climate protection and supply security*; Bros, T., considered whether *the UK gas model is a system hard to justify*; while Pirani, S., explained *the pricing policies for Russian gas based on European netbacks*.

investment decisions but I am not sure anyone has an answer".[125] His conclusion underscores the focus of this book on long term LNG pricing.

Taking a term perspective of the cartel issue, Jaffe and Soligo, assert that a gas producers' group cannot exercise sufficient market influence in the short run. In the long run, however, they speculate that the extent of any producers' group influence would be determined by technological improvement, cost and attractiveness of other competing fuels.[126] Stern cautions that "*the possibility of some type of price setting organization (for gas/LNG) should not be ruled out*"[127] and that the organization is likely to grow quickly in the scenario of a price crisis for exporters.[128] He also speculates on a European or Atlantic based LNG producers group sometime in the future.

The Baker Institute rules out the possibility of an exporters' cartel in the near term because there are many gas exporters "*with diverging interests to exert effective constraints on capacity expansion projects"*.[129] Nevertheless, they conclude that "cartelization should be considered as a potential future feature to global gas markets".[130] In a more recent report[131], the Institute highlights that promoting the development of a competitive global gas market is in the common interest of gas importing countries in Western Europe; North America; and Northeast Asia.

Arguing differently, Hallouche stated that "a *Gas OPEC* is not conceivable strategically, economically or politically, and it is not in the interests or aspirations of most gas exporters". Hallouche, however, considered some possible sub-groupings - OPEC-Form Members; Iran-Qatar-Algeria partnership; African Group and Atlantic

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[125] Jensen, J., *Comments on Gas Demand, Contracts and Prices*, OEF, May 2008.
[126] Jaffe, A. and Soligo, R., *Market Structure in the New Gas Economy: Is Cartelization Possible?* P.27 Para 3, at http://www.rice.edu/energy/publications/geopoliticsofnaturalgas.html
[127] Stern J., *The new security environment for European Gas: Worsening geopolitics and increasing global competition for LNG*, p.17, Para 1, NG 15, OIES, October 2006.
[128] Could the 2008/9 global recession result in such a massive gas price crisis for exporters?
[129] Baker Institute, *The Geopolitics of Natural Gas*, p.9, No. 29, Baker Institute Study, March 2005 at www.rice.edu/energy/publications/geopoliticsofnaturalgas.html
[130] Hartley, P. et'al, *International Influences on the link between U.S. crude oil and natural gas prices* at http://www.rice.edu/energy/publications/docs/natgas/ng_intl_influences-nov07.pdf
[131] Baker Institute Policy Report, *The Global Energy Market*: *Comprehensive Strategies to meet geopolitical and financial risks – The G8, Energy Security and Global Climate Issues*, No.37, July 2008 at http://www.rice.edu/energy/publications/PolicyReports/BIPP_37_July08_GEM.pdf

LNG exporters. He concluded that if the market becomes demand led, a group of exporters could proactively regulate long-term over-supply.[132]

It is apparent that energy economists and petroleum analysts believe that market influence is currently neither feasible nor necessary because gas is different from oil[133] and sold mainly by pipeline and contracts. Despite the constraining factors highlighted in the above review, one does not intend to dismiss the issue of a gas cartel as misleading or conclude that it is inconceivable.[134]

The fact, however, is that there are great potentials for co-operation by gas-rich countries.[135] Why do economists expect an OPEC-style gas cartel in a market that is unlike oil and may never be as liquid as the oil market? Yes, OPEC's approach is one option, which may not be feasible for gas exporters, but it is not the only option neither is price determination the only objective for creating a cartel. Rather than wait for the emergence of a global gas market, exporters could proactively aim to invent a future for gas trade.

The 'gas-cartel' discourse vividly captures the political, institutional and speculative factors that influence investment decisions. Meanwhile, it is evident that the Gas Exporting Countries Forum[136] (GECF) has been the subject of the gas cartel question. While only little is known about this organization today, its character and existence would remain contentiously interesting in future. It would, however, be more interesting and beneficial to know how a gas cartel would determine prices in the emerging global gas market. Addressing the 'how' question is more important because a feasible influence mechanism determines the nature of any producer group. Hence, the need to investigate which market influence path - Contractual, Fiscal, Price or Volume control mechanism[137] - is feasible.

But what is the theoretical basis for uniform pricing?

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[132] Hallouche, H., *The Gas Exporting Countries Forum: Is it really a Gas OPEC in the making?* P.54, Para 1, NG 13, OIES, June 2006.
[133] Chapter Two briefly discusses the differences between oil, pipeline gas and especially LNG.
[134] Wagbara, O., *What are the prospects for a Gas OPEC?* International Gas, October 2008.
[135] For further details, please see Wagbara, O., *How would the Gas Exporting Countries Forum influence gas trade?* Pages 1224-1237, Vol. 35, Issue 2, Energy Policy, February 2007.
[136] An existing Producers' Group subsequently referred to, in this Book, as the **Forum** or **GECF.**
[137] Wagbara, O., *How would the Gas Exporting Countries Forum influence gas trade?* Pages 1224-1237, Vol. 35, Issue 2, Energy Policy, February 2007.

Huge literature exists on the issue of Uniform Pricing as a means of trading final and intermediate products in various industries[138]. Among authors, there is a commonly held view that uniform pricing schemes (within and across national boundaries) are collusive practices: Greenhut and Greenhut assert that it is profit-maximizing in certain competitive situations.[139] Scherer asserts that such pricing systems hamper competition by reducing a "*complicated price quotation problem…to a relatively simple matter of applying the right formula.*"[140]

Norman considers "*uniform pricing a special case of spatial price discrimination*" and built a framework to determine its optimality from a producer's perspective.[141] According to him, firms in sectors that are monopolistic or collusive oligopolies are not constrained to maximize profit and, given a sales revenue maximization objective, uniform pricing can be optimal[142]. "*In a uniform delivered pricing system*, according to Espinosa, *each firm quotes the same price to all the customers".*[143]

He tried to reconcile the arguments relating to Uniform Delivered Pricing and concludes that such systems "*cannot be labelled as facilitating collusive practices in all instances;* (rather) *the structure of the market should be taken into consideration"*.[144] From available literature, the following conditions are necessary[145] for the application of Uniform Pricing (from an exporter's point of view - at least):

(i) *Profit in the industry should be loosely constrained*:
For LNG Trade, part of exporters' profit is constrained by contracted liquefaction. While uncontracted capacity offers additional (unrestricted) profitability through the spot market.

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[138] Cement Industry; Internet access; Steel, as well as, British Coal Industry (in 1930).
[139] Greenhut, J. and Greenhut, M. *Spatial price discrimination, competition and locational effects* Volume 42, Economica, 1975
[140] Scherer, F. as quoted in Espinosa, M., *Delivered pricing, FOB pricing, and collusion in spatial markets*. Vol. 23, No.1, RAND Journal of Economics, Spring 1992.
[141] Norman, G., *Uniform Pricing as an Optimal Spatial Pricing Policy*, Vol. 48, Economica, New Series, Vol. 48, No. 189. (February, 1981).
[142] *Ibid*
[143] Espinosa, M., *Delivered pricing, FOB pricing, and collusion in spatial markets*. Vol. 23, No.1, RAND Journal of Economics, Spring 1992.
[144] *Ibid*
[145] The extent to which they are sufficient would be determined by consumers' response to the Uniform Price. However, Consumers' response is not extensively covered in this work.

(ii) *The market area for each exporter restricted relative to the distance* and, consequently, **(iii)** *Low marginal costs of production relative to the unit elastic price*: In the case of LNG, each additional liquefaction train incurs lower marginal cost per unit relative to existing trains.

(**iv**) *Low unit transport costs within a particular spatial market*[146]: This relates to the high cost of transporting LNG for distances less than 3,000 Kilometres.[147]

In this chapter, the essential elements of the study has been presented in addition to a literature review to underpin the main research problem - market-based pricing for LNG may be less remunerative and uncertain for exporters and the possibility of rent-seeking could encourage them to collude and/or collectively adopt some market controlling mechanism. To test the viability of such a mechanism is a key objective of this work. So, to prepare the work area, it is necessary to describe the context of LNG trade – this is an aim of the next chapter.

[146] Norman, G., *Uniform Pricing as an Optimal Spatial Pricing Policy*, Vol. 48, Economica, New Series, Vol. 48, No. 189. (February, 1981).
[147] Compared to pipeline cost but depending on the location (onshore/offshore); geographical region; pipeline pressure (high/low); and number of LNG Trains. *See* Jensen, J., *The future of gas transportation in the Middle East: LNG, GTL and Pipelines*, 2004.

CHAPTER TWO

ATLANTIC BASIN LNG TRADE

2.1.1 Introduction

This chapter sets the scene of the book by describing the context[148] of LNG trade. Starting with the characteristics of LNG[149], it traces the history of LNG trade from global, regional and national perspectives. To answer the main research question, this discourse helps to determine which *could be the key countries in an LNG cartel and why.* Through the narrative, justification[150] is made for the choice[151] of countries simulated in Chapter Four[152]. In addition, it expounds on the demand potentials of LNG in the importing markets.[153]

2.1.2 The nature of LNG

Gas is formed out of organic material deposited in the earth crust. But, compared to crude oil and coal, natural gas is an environmentally superior[154] fuel which is evenly distributed across the globe. One would therefore expect that gas would be used more widely than the other fuels. Unfortunately, this has not been the case due to its nature - the challenge of handling gas[155] and the cost of transportation. Initially, it was transported by pipelines only and so gas trade was local, national or continental - but limited by the reach of pipelines.

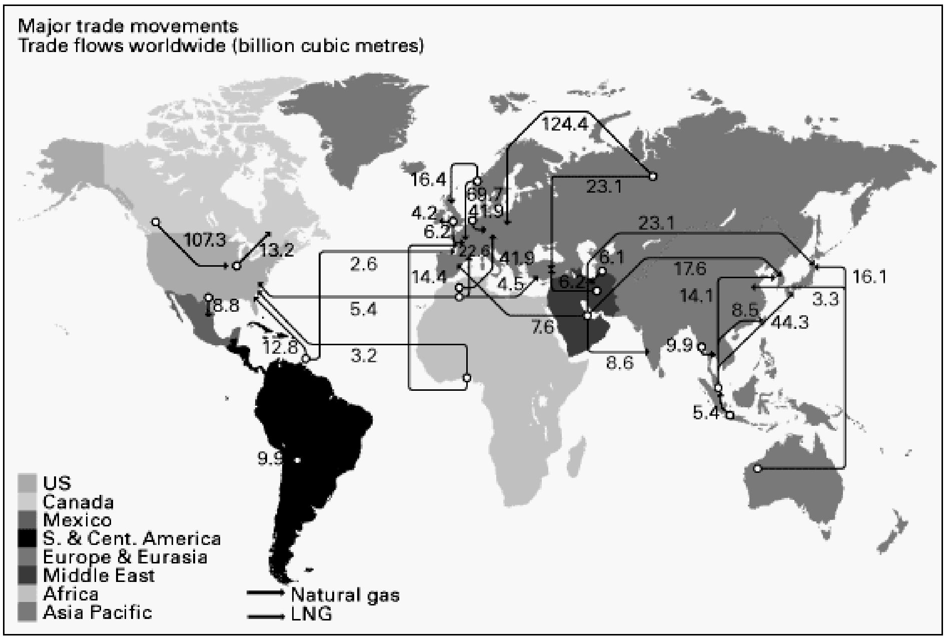
Consequently, each national or regional pipeline gas market was defined and characterized by its peculiar structure, demand patterns, supply, pricing and other socio-economic variables. This situation resulted in operational, commercial and structural difficulties. First, market interaction was limited or none existent due to bilateral gas sales contracts and the rigid nature of pipelines. Second, the cost of

[148] Export options/routes; existing and potential supply capacity; as well as; future investment scenario.
[149] Both as a commodity and project, LNG is different from crude oil and pipeline gas.
[150] The countries were chosen based on their participation or ability to participate (liquefaction capacity and market share) in the Atlantic Basin LNG market within the research's time frame - between 2005 and 2013.
[151] Emphasis shall be on the main countries that participate in Atlantic Basin LNG trade: Algeria; Egypt; Libya; Nigeria; Qatar; as well as, Trinidad and Tobago (subsequently referred to as Trinidad in this Book).
[152] A few excluded countries are also discussed.
[153] It is generally a discussion of regional demand trend/issues in North America and Europe. But in Chapter Four, the following countries are used to simulate Atlantic Basin LNG Trade: US; Spain; Italy; France; UK.
[154] Relative to crude oil, natural gas has a lower energy-to-volume ratio.
[155] Like potential difference determines the direction of electric current, so also is pressure or temperature used to chart the flow of natural gas from one point to another.

building a pipeline is almost "proportionate[156] to its length, for any given dimension of the pipeline"[157]. Besides, transit pipelines also create other geopolitical issues. Moreover, the seasonal variation of gas demand makes storage capacity[158] necessary but with its cost implications for gas traders/importers.

To overcome some these constraints, experiments in the liquefaction of natural gas began in 1934 in the USSR and 1940 in the United States of America.[159] Similarly, the CAMEL LNG *transport* venture was initiated in 1961 to carry gas from Hassi R'Mel in Algeria.[160] Although gas is still transported by pipeline, LNG has completely changed the perception of gas and the conventional regional isolation of pipeline markets (as Figure 2.1 shows). In some regional gas markets, the need for additional storage capacity[161] is an important gap filled by LNG.

Figure 2.1 Major trade movements[162]



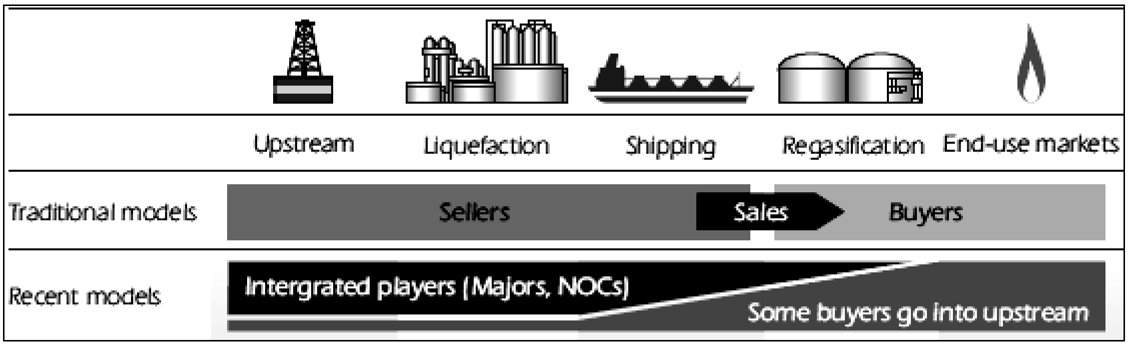
[156] If other externalities are taken into consideration it could cost more.
[157] Hannesson, R., Petroleum Economics: Issues and Strategies of Oil and Gas Production, 1998.
[158] By raising the pressure some storage can be created in pipeline or tankers.
[159] Rojey, A., et'al, Natural Gas: Production, Processing and Transport, 1997.
[160] More detailed history of LNG trade by Algeria is provided in section 2.3.1.
[161] The need for more storage capacity is increasing in many gas markets (especially within Europe) due to declining domestic production and uncertain pipeline imports. This issue is discussed some more in section 2.2 below.
[162] BP Statistical Review of World Energy, June 2008.

At this point, some characteristics of LNG are worth highlighting – in contrast with oil - before considering how it has evolved across regions:

1. <u>Long term contracts</u>

LNG differs from oil because it is traded mainly through long-term contracts.[163] As is peculiar to natural gas, it also involves high transport and storage costs. Long-term contracts serve as vehicle for sharing upfront investment risks in LNG projects. Through contracts, LNG projects confer equity on project partners, in the form of liquefaction capacity and off-take rights, which they use to service downstream supply commitments. Because of its non- transparent nature, the long term contracts market for LNG is illiquid and non-competitive. Developments in the market, however, indicate that exporters are keen to maintain the long term contract regime.[164]

Figure 2.2 Traditional and newer models of LNG[165]



Like in the oil market, some derivatives - futures, options and swaps - now exist in some natural gas markets. While this is not the case for LNG, natural gas futures contract is not yet an efficient instrument for hedging against price and volume risks. However, the following vital deductions are worth noting:

- the prevalent long-term LNG take-or-pay (TOP) contracts (and pricing) structure previously existed in the oil market and;
- the use of spot market (NBP and Henry Hub) prices to index long-term contracts now is similar to the evolutionary path of oil trade;

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[163] So far, spot LNG has been a means of satisfying peak natural gas demand mainly during extreme winter and summer periods in Europe and North America.

[164] Wagbara, O., *To what extent is a liquid LNG Hub, in the Middle East, feasible?* International Energy Law Review, Issue 3, 2008.

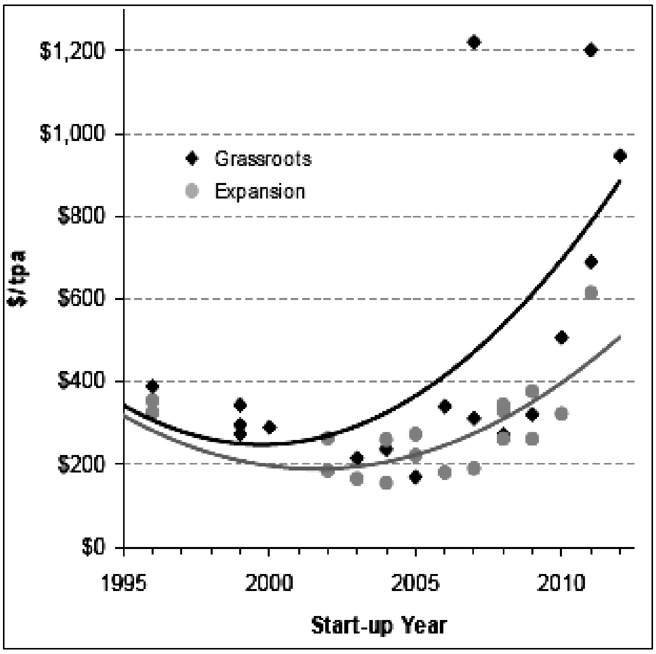
[165] IEA, <u>Natural Gas Market Review 2007 *Security in a Globalising Market to 2015*</u>, 2007.

- As was the case with oil, LNG contracts are becoming more flexible and sometimes involve cargo swaps[166]. Figure 2.2 shows the traditional and newer models of LNG business.

2. <u>Cost Structure</u>

LNG has a high fixed and low operating cost structure. As a result the initial trains required project finance tied to long term sales agreements.[167] Technological advancements later reduced the cost of LNG projects[168] and so enhanced the economic viability of *previously* stranded gas reserves through LNG exports.

Figure 2.3 Liquefaction EPC costs (2008 USD tpa)[169]



The initial reduction in engineering, procurement and construction (EPC) costs, however, ended in 2004. Subsequently, the trend was reversed (as in Figure 2.3) because of construction capacity constraint and rising cost of raw materials

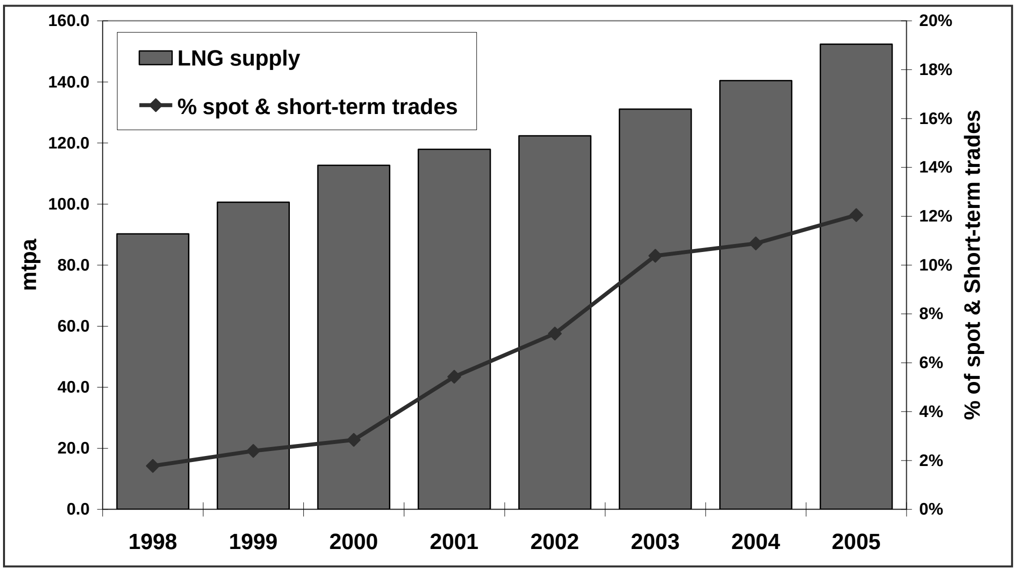
[166] Shook, B. and Jaffe, A.M., *Developments in Atlantic Basin LNG: Implications for Japan*, Working Paper
[167] Project finance, then, also required other contracts across the supply chain (from well head to regasification terminal).
[168] Across the LNG value chain – Liquefaction, shipping and regasification.
[169] Adamchak, F., *Global LNG supply and competition: Long and short term issues.* Presentation to the National Capital Area Chapter of the United States Association for Energy Economics, on 19 September, 2008.

(especially steel).[170] Consequently, only four supply-side Final Investment Decisions (FIDs) were taken between 2005 and 2008.

3. Transport costs and market interaction

Like oil, LNG's ability to flow in three dimensional space and the consequent technical economies of scale revolutionized gas trade globally. The low transport cost element in the delivered price, per unit of distance, induces rapid arbitrage in response to regional price differentials[171]. From the onset of this decade, spot trading (Figure 2.4), price arbitrage and diversion of LNG vessels have occurred across the globe. Invariably, the high cost of transportation does not always restrict gas trade interregional.

Figure 2.4 Short-term and spot trade as a % of LNG Supply[172]



While the process results in crude oil price convergence, the same does not apply to LNG due to the lack of an international price marker. This trend, alongside growing intra-continental trade, has contributed to the integration of gas markets and could enhance opportunities for influencing LNG trade.

4. Spare Capacity:

[170] Cost patterns could change again but its direction would depend on how the unraveling global economic crisis affects the determinants of EPC costs.
[171] Horsnell, P; Oil in Asia: Markets, Trading, Refining and Deregulation, 1997.
[172] http://portale.unibocconi.it/wps/allegatiCTP/30maggio.pdf

The cost structure and contractual nature of LNG, described above, make it expensive and complicated to hold uncontracted liquefaction[173] or regasification[174] capacity. There could be geological cost advantages, relating to gas production, for some exporters in the Middle East or Africa, but most LNG projects have similar[175] cost structure. Compared to the cost of production, in some countries, it is less costly (but also economically challenging) to hold spare crude oil capacity.[176]

In sum, the above description shows how LNG trade differs from natural gas markets and the global oil market. While it is not a framework used directly for analyses, it justifies the fact that LNG is different from most internationally traded commodities (as earlier stated in section 1.5.4) The narrative also creates the context for understanding LNG trade. Considering the staggered evolution of LNG, the following discourse highlights its development and importance in different gas markets.

2.2 DEVELOPMENT OF LNG TRADE

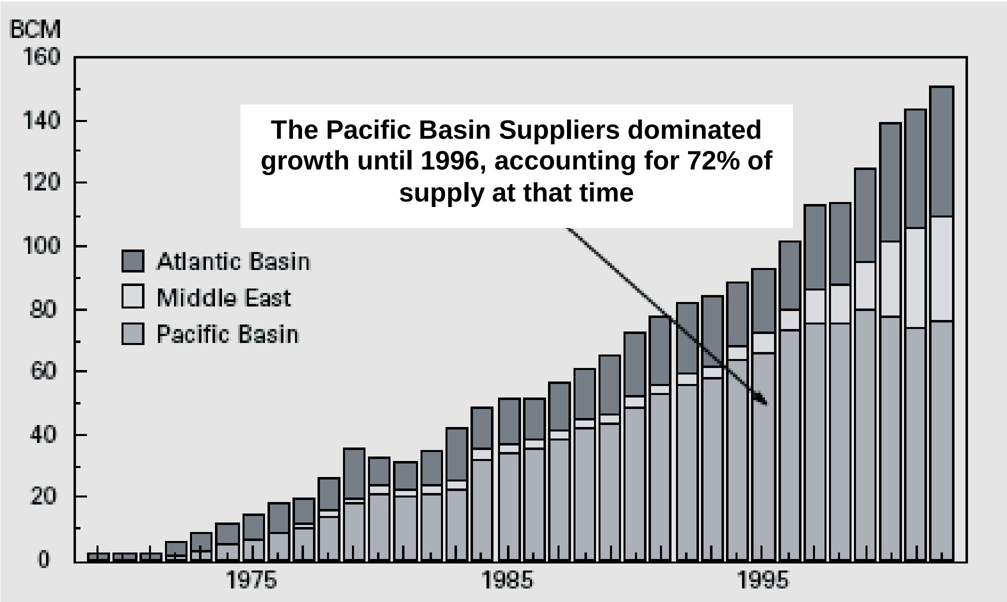
Algeria's CAMEL project set an auspicious stage for the commercial trading of LNG globally.[177] And by 1969 three other trades had began – two of them were in the Atlantic Basin.[178] The third strand of trade in that year marked the beginning of commercial LNG export into Asia Pacific and it was from the Kenai terminal Alaska (US) to Japan.[179]

Then, LNG was the only source of gas supply in Japan, Korea and Taiwan - imported mainly from Indonesia, Brunei and Malaysia (as Figure 2.5 indicates). More so, during the period 1975 to 1996 LNG demand in the region rose by an average of 3.31Billion M^3 per year.[180] As LNG trade boomed in the Pacific Basin,

[173] It is relatively more expensive even when liquefaction capacity is strategically held for spot trading purposes.
[174] Idle regasification terminals are sometimes used for self-contracting and to gain/secure downstream access. Whatever the case may be, there are economic implications for holding such capacity.
[175] Scale-related cost advantages are also another exception.
[176] Here lies OPEC's ability to influence price (even in a competitive market scenario) given inelastic demand.
[177] Jensen, J., The development of a global LNG market: Is it likely? If so when? 2004.
[178] One of them was from Libya to Spain and Italy, while the other was from Algeria to France.
[179] http://tonto.eia.doe.gov/energy_in_brief/liquefied_natural_gas_lng.cfm
[180] Jensen, J., The development of a global LNG market: Is it likely? If so when? 2004.

interest was being lost in the Atlantic Basin - trade was crippled by gas price disputes and oil price shocks.[181]

Figure 2.5 Historical sources of LNG Exports[182]



Initially, Indonesia was the largest exporter of LNG in the world, but as its production declined, new LNG producers emerged in the Atlantic Basin (Middle East and Africa). By year 2000 Qatar had become an LNG importer and one of the top five LNG exporters (as Table 2.1 indicates). Qatar, which was third largest exporter in 2005, has taken over from Indonesia as the biggest exporter. It is also notable that as Algeria's proportion of LNG exports declined, Nigeria emerged in the top five within ten years of becoming an LNG exporter. Atlantic Basin exporters are contributing significantly to Pacific LNG supplies.[183]

So far, Japan has remained the dominant LNG importer globally and consumption continues to soar in the Pacific - an average of 5.9% between 1997

[181] More discussion on this is provided in Section 2.2.1 below.
[182] Source: Cedigaz
[183] Fesharaki, F., *Globalization of LNG Markets: East versus West Prices and Flows*, Presentation at the 2nd IAEE Asian Conference, Perth Australia; November, 2008.

and 2007.[184] And, trade almost doubled within Asia Pacific in those ten years – with a 6.1% rise in 2008.[185]

Table 2.1 Top Five LNG Exporters in the World (1995-2008)[186]

	1995 (%)	2000 (%)	2005 (%)	2008 (%)
Ranking is based on % of LNG export relative to global total in that year	Indonesia (36.4) Algeria (19.2) Malaysia (14.1) Australia (10.7) Brunei (9.3)	Indones. (26.4) Algeria (19.3) Malaysia (15) Qatar (10.5) Australia (7.5)	Indones. (16.7) Malaysia (15.1) Qatar (14.4) Algeria (13.6) Trinidad (7.4)	Qatar (17.5) Malaysia (13) Indones. (11.9) Algeria (9.7) Nigeria (9.1)
Total: Atlantic[187]	**19.2%**	**29.8%**	**35.4%**	**36.3%**
Total: Pacific[188]	**61.2%**	**48.9%**	**31.8%**	**24.9%**

Source: Extracted by author from BP Statistical Review of World Energy and US EIA

However, a notable pattern obvious in Table 2.2 is that the proportion of global LNG imported by Japan since 1995 has been declining. This could be attributable to the increasing demand for LNG globally and the declining proportion of global LNG imported by Pacific countries (in the Top Five ranking). For instance, according to CEDIGAZ, in 2008 Asian imports grew by 4.8% - but, Japan recorded only 3.7% increase in LNG imports while, China, Taiwan and South Korea had 15%, 9.7% and 8.1% rise in imports respectively. Despite the effects of the global economics crisis, this trend could continue as energy demand in China and India persists.

On the other hand, the historical data reveals that LNG demand has been increasing fast in the Atlantic Basin. Especially, the Spanish proportion has been rising in the last fourteen years, in addition to the US market – which emerged as one of the top five LNG importers in 2005.

[184] BP Statistical Review of World Energy, June 2008.
[185] GIIGNL; *The LNG industry*, 2008
[186] This Table has been computed with data from the referenced sources.
[187] This row is a summation, from the top five, of the percentages of Atlantic Basin Exporters.
[188] This row is a summation, from the top five, of the percentages of Pacific Basin Exporters.

Table 2.2 Top Five LNG Importers in the World (1995-2008)[189]

	1995 (%)	2000 (%)	2005 (%)	2008 (%)
Ranking based on % of global LNG export in that year	Japan (64.3) S. Korea (9.9) France (7.6) Spain (7.4) Belgium (5.1)	Japan (53.9) S. Korea (13.6) France (7.6) Spain (5.5) USA (4.6)	Japan (40.4) S. Korea (16.1) Spain (11.6) USA (9.5) France (6.8)	Japan (34.6) S. Korea (16.1) Spain (12.7) France (5.6) Taiwan (5.3)
Total: Atlantic[190]	**20.1%**	**17.7%**	**27.9%**	**18.3%**
Total: Pacific[191]	**74.2%**	**67.5%**	**56.5%**	**56%**

Source: Extracted by author from BP Statistical Review of World Energy and US EIA

Atlantic Basin Gas Markets

In the Atlantic Basin, town gas[192] had been traded in Europe and North America long before natural gas was discovered - in the 20th century. As a result, most countries in the region had their natural gas industry even before the advent of cross border gas trade. Now, gas trade in the Atlantic Basin consists of two regional pipeline markets[193] and LNG Trade.[194] LNG has played a significant role in linking[195] the two regional gas markets in the course of their evolution. But what is the role LNG these markets and how has it evolved over time in the Atlantic Basin?

The first commercial delivery of LNG in the Atlantic Basin was from Algeria to Britain - Canvey Island terminal - in 1964.[196] Earlier on, in 1958, *Methane Pioneer*[197] - the first LNG tanker in the world – had demonstrated[198] the safety of ocean travel by carrying 5,000m^3 **across** the Atlantic from Lake Charles in the United States to England.[199] Over the years, North America and Europe began to rely on LNG as a

[189] National LNG imports as a percentage of total LNG imports.
[190] This is merely a summation of the percentages of Atlantic Basin LNG Importers in the top five.
[191] This is merely a summation of the percentages of Pacific Basin LNG Importers in the top five.
[192] Town Gas was manufactured gas from coal - used and traded locally in the 19th Century.
[193] North American natural gas market and European natural gas markets
[194] Supply to the Atlantic Basin LNG market emanates from exporters in South and Central America; West Africa; Middle East and North America. The main LNG exporters in these regions are described extensively in section 2.3.
[195] These markets interacted sparingly before the LNG revolution. Some similarities have been observed in the nature of market restructuring and regulatory framework.
[196] Chabrelie, M., *LNG: A Commodity in the Making*, pg.1, paragraph 1, PANORAMA 2006 at http://www.ifp.fr/IFP/en/events/panorama/IFP-Panorama06_10-GNL-VA.pdf
[197] Jensen, J., The development of a global LNG market: Is it likely? If so when? 2004.
[198] Seven other trips were undertaken.
[199] Sullivan J. A. and Shook, B., *Ships, Crews stumbling Blocks in developing LNG Supply Chains*, p.3, Natural Gas Week, February 6, 2006.

source of marginal gas supply. Perhaps, it would be necessary to review the history and role of LNG in each importing country before considering the feasibility of market influence.

2.2.1 North America[200]

North America pioneered gas market reforms through the partial lifting of wellhead price controls in the Natural Gas Policy Act of 1978. Subsequently, in 1989, the Federal Energy Regulatory Commission (FERC)'s Order 500H[201] completed the liberalization process and gas price deregulation in the US. The Canadian Agreement on Natural Gas Prices and Markets unbundled gas sales in 1985.[202] The reform process in Mexico is progressing and already has a linkage with the US Market. So, gas prices are unregulated, but FERC regulates operations of the major – interstate – pipeline network (in the US), while the NEB regulates the Canadian inter-provincial pipelines.

The region has the most liquid and integrated gas market in the world – it incorporates the US, Canada and Mexico. It is made up of producers, storage companies, pipeline companies, 'aggregators' (i.e. marketers), local distribution companies (LDCs) and consumers. Having developed gas-to-gas competition, the US has over 8,000 gas producers, while Canada has about 3,000. So, shippers purchase gas from producers, as well as, transportation services from pipeline companies for shipping the gas. With such liquidity, domestic gas producers respond to changes in prices. When prices are high, gas production increases[203] but when price falls due to decrease in demand, production falls.

The US gas market had encountered LNG in the course of evolving – the first liquefaction plant was built in 1912 and followed by the premier commercial plant in Ohio (1941).[204] By 1969, the first commercial LNG export left Kenai terminal

[200] United States of America is the focus of this sub-section but it reflects Canada and Mexico in the American picture.
[201] Sometimes, FERC's Order 500H is referred to as Wellhead Decontrol Act.
[202] IEA; Security of Gas Supply in Open Markets: LNG & Power at a turning point, 2004.
[203] An exception is during extreme weather conditions when demand is very high. At such periods, spot LNG imports are also attracted.
[204] http://tonto.eia.doe.gov/energy_in_brief/liquefied_natural_gas_lng.cfm

Alaska[205] for Japan.[206] Subsequently, three LNG projects,[207] between American Importers and Algeria's Sonatrach, were agreed in the 1970s.[208] By the 1980s, however, the prospects of LNG imports in the US diminished dramatically - due to a number of reasons.

One key factor was market restructuring which significantly transformed the US domestic gas market, as well as, price fundamentals. A second reason was the rejection[209] of two proposed Algerian LNG import projects. The regulatory body cited similar reasons – related to national and regional gas supply considerations - for turning down both applications.[210] Another very important factor was the price dispute between Algeria and its American LNG importers – discussed in more detail below.

Sonatrach's attempt to unilaterally hike the price of LNG in the contract with El Paso, in October 1979, started the price dispute.[211] El Paso argued the action was a breach of previously agreed Contract terms and that it had been restrained, by the US Government, from accepting the new price. This led to the suspension of deliveries to the terminal in April 1980 and further negotiations with US DOE.[212] Negotiations reached an irrevocable end on 18 February 1981 and the El Paso contract came to an end with the writing off of related assets.[213] Almost about the same time, supplies for the Trunkline LNG Contract (signed in 1975) was being delayed by Algeria for technical difficulties. Subsequently, the pricing terms in the contract was amended to include escalation based on crude oil. This gave rise to the indefinite suspension of LNG purchases by Trunkline for financial reasons.[214]

[205] The oldest LNG export terminal in North America
[206] Since then it has exported LNG to Japan almost continuously.
[207] The LNG projects - Distrigas; El Paso and Trunkline – had also been approved by US regulatory authorities.
[208] Stern, J., Natural Gas in North America and Asia, 1985.
[209] Within a three-day period, in 1978, both projects – El Paso II and TAPCO (Tenneco) rejected by the US governments Economic Regulatory Administration.
[210] For more details, see Stern, J., Natural Gas in North America and Asia, 1985.
[211] Stern, J., Natural Gas in North America and Asia, 1985.
[212] An agreement was almost reached, but the negotiated were complicated by a change in US Government Administration from Jimmy Carter to Ronald Reagan in late 1980.
[213] Stern, J., Natural Gas in North America and Asia, 1985.
[214] Stern, J., Natural Gas in North America and Asia, 1985.

Apparently, the regulatory authorities – state and federal – refused to allow LNG to be sold at prices higher than market rates. Amidst falling domestic gas prices, it was uneconomical for US importers to resell the imported LNG locally. One reason being that deregulation brought forth a huge volume of new gas which reduced prices such that LNG could not compete in the US for nearly two decades.

Besides, new contracts could not be signed because the US Government was concerned about the potential implications of Sonatrach's demand[215] on Mexican and Canadian gas prices.[216] As a result, three import terminals at Lake Charles, Elba Island and Cove Point were idle. Nevertheless, US LNG imports did not come to a complete halt. Rather, Distrigas continued to receive LNG at the Everett terminal throughout deregulation. A major reason being that in New England, gas prices were high enough to allow LNG to be resold profitably.[217]

Table 2.3 US Gas Demand and Imports (1973-2008) MMcf

Years	Consumption	Total Gas Imports	Pipeline Imports	LNG Imports
1973	22,049,363.00	1,032,903.294	1,029,514.984	3,388.310
1975	19,537,593.00	953,007.609	948,114.660	4,892.949
1980	19,877,293.00	984,767	898,917.000	85,850.000
1985	17,280,943.00	949,715	926,056.000	23,659.000
1990	19,173,556.00	1,532,258.848	1,448,065.483	84,193.365
1995	22,206,889.00	2,841,048.409	2,823,129.959	17,918.450
2000	23,333,120.75	3,781,602.987	3,555,567.466	226,035.521
2005	22,010,596.27	4,341,034.052	3,709,773.607	631,260.445
2008	23,206,444.62	3,980,778.897	3,629,080.468	351,698.429

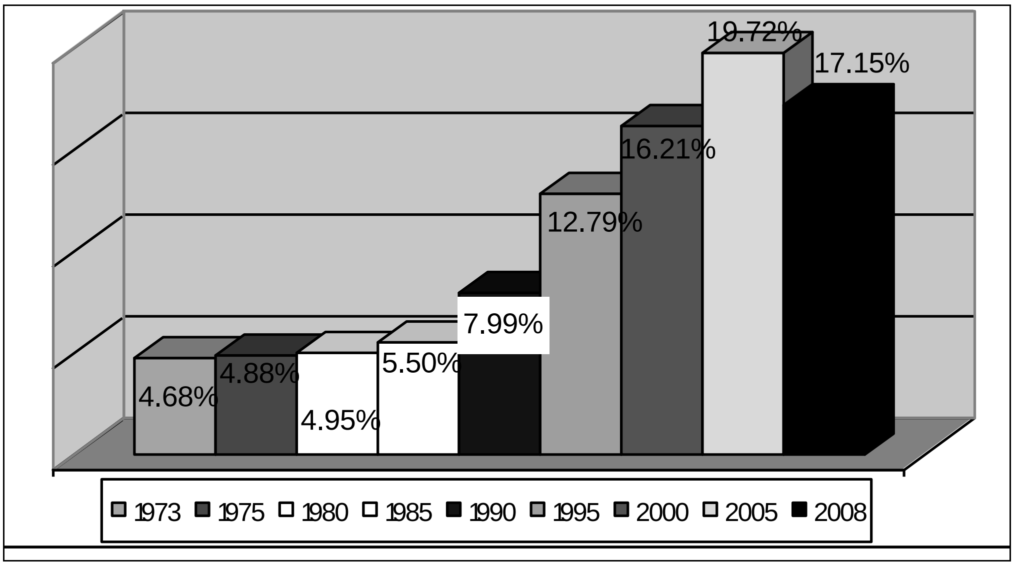
Source: US Energy Information Administration

The above discourse is evident in Table 2.3. Noticeably, LNG imports were low in the mid 1980s and 1990s – when most import terminals were idle. Amidst the growth in pipeline imports and demand, the volumes of LNG imports dropped drastically between 1980 and 1985, as well as, 1990 and 1995.

[215] As well as, the effects of additional LNG supply from Algeria.
[216] Stern, J., Natural Gas in North America and Asia, 1985.
[217] And when not high enough, Distrigas' renegotiation contract (on netback basis) gave Sonatrach the option of refusing a delivery if it did not like the prevailing price.

It was not until the late 1990s-2000 that LNG importation was revived in the US – two idle terminals were reopened, five new ones have been commissioned since 2005 and another three expected by 2010[218]. Ironically, this revival was driven by unexpected decline in domestic production, increased energy demand (globally) and corresponding rise in oil and gas prices.[219]

Figure 2.7 History of US Gas imports as a % of Demand[220]



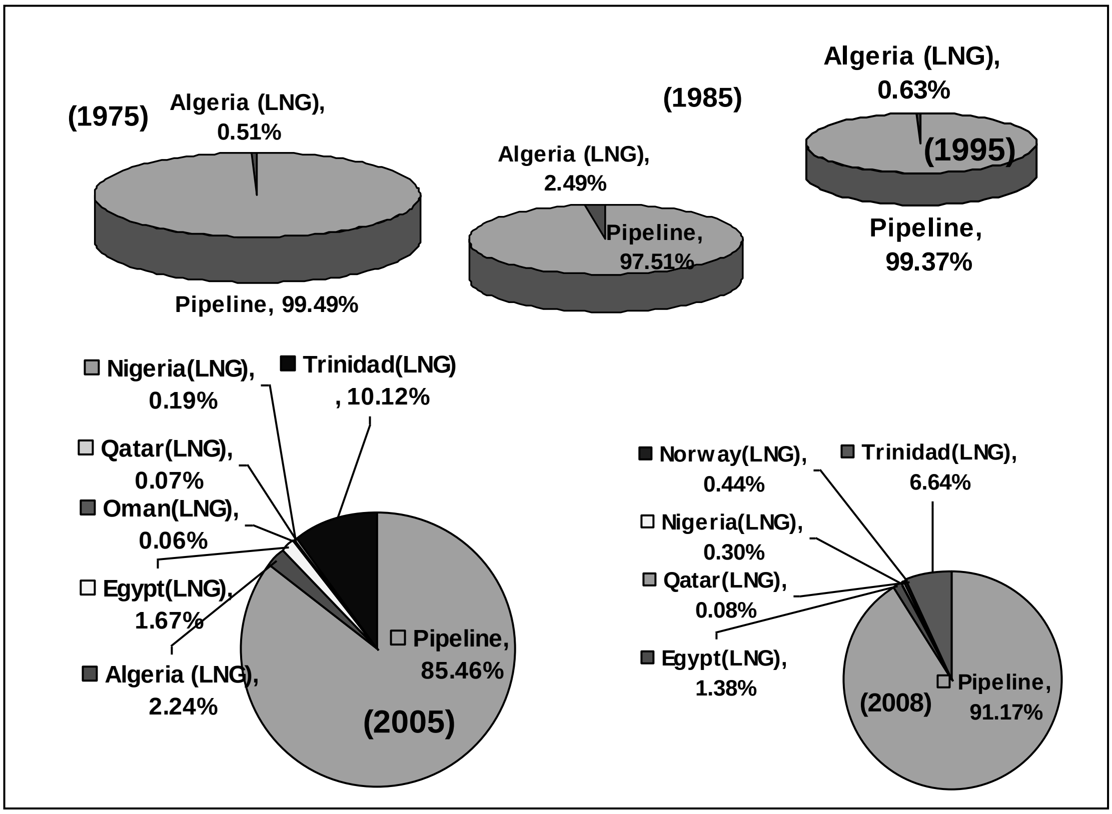
Surprisingly, in the last fifteen years, the volume of US gas imports increased faster than consumption (as Figure 2.7 shows).[221] But, LNG imports have not increased to a significant proportion of US consumption[222] over the years. Rather, it has remained below 3% most of the time - another reason why Algeria's attempt at "price control" failed.

Yet, the sources of US gas imports (as Figure 2.9 indicates) have also increased over the years. Moreover, it is noteworthy that LNG imports are diversified to the extent that no exporter (apart from Trinidad) supplies more than 3% of US LNG imports. Although, it is primarily an importer of gas, the US also exports - Mexico receives regular truck-loads of LNG from the US. In addition to US imports, Mexico

[218] Petroleum Economist, April 2009.
[219] In addition to other drivers of LNG boom highlighted in Chapter One (page 3).
[220] Data extracted by author from http://tonto.eia.doe.gov/dnav/ng/ng_move_impc_s1_m.htm
[221] For instance, in 2005 was slightly lower than the volume in 1973, but imports more than tripled.
[222] When compared to pipeline gas imports.

also imports LNG cargoes at the Altamira terminal from other countries – Nigeria,[223] Egypt, Qatar, as well as, Trinidad and Tobago.[224]

Figure 2.9 Sources of US gas imports by country/pipeline/LNG[225]



Meanwhile, Canadian gas export to the US is declining, while US conventional gas production peaked four years ago.[226] With declining production in Western Canadian Sedimentary Basin,[227] Kitimat LNG[228] has been proposed for the west coast of Canada.[229] When matched against projected demand estimates, it is likely[230] that the North American natural gas market would increasingly depend on LNG[231] (as indicated in Figure 2.10) and unconventional gas[232].

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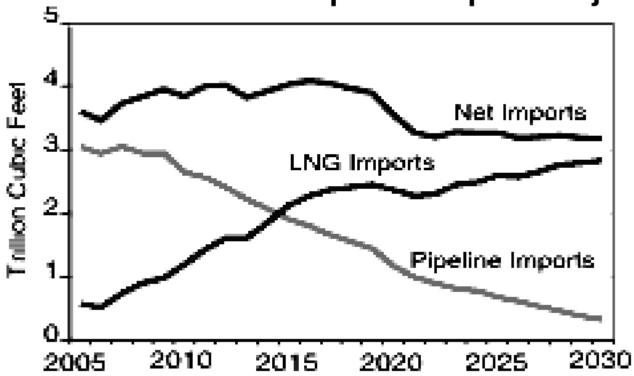
[223] Mexico imports from Nigeria mainly (apart from the US). According to the US EIA, for instance, in 2006 Mexico imported about 48.3% of its LNG from Nigeria.
[224] http://www.eia.doe.gov/emeu/international/LNGimp2006.html
[225] Data extracted by the author from US Energy Information Administration database.
[226] Yergin, D., *Testimony to the Joint Economic Committee United States Congress*, October 7, 2004.
[227] CEDIGAZ., *2008 natural Gas Year in Review*. Press Release, May, 2009.
[228] Supplies are expected from the 5mtpa export terminal - the second in North America (after Kenai Terminal in Alaska).
[229] Dawson, T, *North American gas' reversal of* fortune. Petroleum Economist, April 2009.
[230] In 2006, the US, gas demand was about 60Bcf/d while its production decline curve is projected at 17Bcf/d per year (excluding shale gas).
[231] http://tonto.eia.doe.gov/energy_in_brief/liquefied_natural_gas_lng.cfm

The US has, therefore, led several regulatory changes to encourage investment in LNG infrastructure. The most outstanding of these changes was FERC's elimination of "open-season" requirements. Arguably, the 'Hackberry Decision' (in the US) set the stage for exemption of LNG regasification terminals from third party access rules in Europe. In effect, US LNG regime offers clear incentives, "freedom to adopt the most suitable business model and regulatory certainty"[233] to investors.

Figure 2.10 US LNG and Pipeline Import Projection



Source: Energy Information Administration, Annual Energy Outlook 2008 (March 2008).

Consequently, LNG import rose from 2.5% of US gas imports in 1985 to 16.7% in 2007.[234] In 2008, however, US LNG imports fell to 1bcf per day[235] and this has been attributed to the increased shale gas production and global financial crisis (which began in the US that year). But, since October 2008, the number of operational gas drilling rigs in North America has decreased by forty percent.[236]

Perhaps, amongst other factors, the inability of US importers to compete in a global LNG market may have contributed more to the decline in LNG imports in 2008. Besides, the US Energy Information Administration expects LNG imports to

[232] In the long term shale gas could contribute significantly to US gas supply. Along this line, there are indications that Kitimat LNG may have applied for permits to export LNG, from shale gas production, to Japan. At present, however, due to the economic recession, the pace of drilling has slumped. Petroleum Economist, June 2009.
[233] Trischmann, H., *LNG into Europe: European regulation – American style?* Issue 12, I.E.L.T.R. 2004.
[234] BP Statistical Review of World Energy 2008
[235] Petroleum Economist, April 2009.
[236] Rogers, H., 'Letter to the Editor' in respect of *LNG Trading: Overview and Challenges*, OIES, May 2009.

overtake pipeline imports in the next decade.[237] Despite the above outlook, it is notable that LNG is still a marginal supply and price taker in the US market.[238]

Do these developments guarantee that North America would have significant effects on Atlantic Basin LNG trade in the future? Potential US impact would vary over time depending on interaction between domestic gas prices and international LNG prices, as well as, the effect of unutilized regasification capacity[239]. Although new terminals are expected,[240] LNG involves price risk – "the willingness to bet that the long-term marginal cost of supply will be lower than the prevailing US gas price"[241]. In 2005, for instance, Europe, Japan and Korea did outbid the US for LNG Cargoes and caused it to "fall victim to intense trans-Atlantic pull in both summer and winter"[242].

At present, there are about seven proposed or on-going regasification terminal projects in Canada, while Mexico has about five. In the East Coast of the United States[243] over forty (40) LNG regasification terminals have been proposed. Whether they are eventually built would depend on EPC costs, crude oil price and domestic gas production[244]. Besides, it may be too early to speculate on the potential and ultimate impact of the global economic crisis on LNG trade.

To a large extent, US government's energy policy could affect the future role of LNG in the US energy spectrum. Until then, the multiplicity of regasification terminals and perhaps an excess capacity in this segment of the business would affect the overall LNG trade. If gas is in short supply, gas will flow to those consumers who are willing to pay the highest price. A large number of terminals offer opportunity for price arbitrage even within North America and such a

[237] http://tonto.eia.doe.gov/energy_in_brief/liquefied_natural_gas_lng.cfm
[238] An extensive discussion of LNG pricing in the US is presented in Chapter Three (sections 3.1.2.5 and 3.2.3).
[239] Foss, M., *United States Natural Gas Prices to 2015*, at http://www.oxfordenergy.org/pdfs/NG18.pdf
[240] As indicated in Figure 2.9.
[241] Deutsche Bank, *LNG: Going… going… Gone* Global, London, Global Equity Research, 2nd May 2003
[242] Energy Intelligence Group, *US feels global shocks*, p.2, paragraph 2, World Gas Intelligence, Vol. XVII, No.5, February 1, 2006
[243] Stern, J., *Security of Supply: case study of European gas markets*, CEPMLP Lecture on March 6, 2006, in University of Dundee.
[244] Shale gas production, especially: which has increased drastically recently. This increased production affected LNG imports in 2008, but its sustainability remains uncertain.

possibility[245] could reduce market control options. However, if the supply is abundant, will the producers try to control the price or volume to remain viable? In the light of such issues, it would be important to tell which scenario is likely to occur in the future and how such developments could influence gas trade?

2.2.2 Europe

Europe's gas industry has come a long way.[246] The Dutch Groningen[247] field, which was the first major discovery (in 1959) started commercial production in 1965. Thereafter, UK's North Sea gas fields were discovered in the late 1960s and the Norwegian offshore Troll field discovered in 1980.[248] The geography of Europe, with short distances between gas production points and areas of use provides an attractive market for gas to compete with other fuels. After North America and the FSU, the European gas industry is the third largest regional market - demand grew on average by 3.7% annually from 1973 to 2000.[249]

Gas markets in Western Europe were initially organized around a few players, especially government monopolies and merchant transmission companies.[250] The development of Soviet (now FSU) gas resources led to the creation of gas markets in Continental European. The industry opened up with deliveries of gas to various countries in the region within the framework of the Council for Mutual Economic Assistance (CMEA[251]). Thereafter, some joint cooperation (barter) projects with the Soviet states significantly expanded gas trade in the 1970s and 1980s.

Following various EU Directives[252] and structural reforms, by July 2004 European natural gas markets became open to 530,000 industrial sites.[253] The Policy

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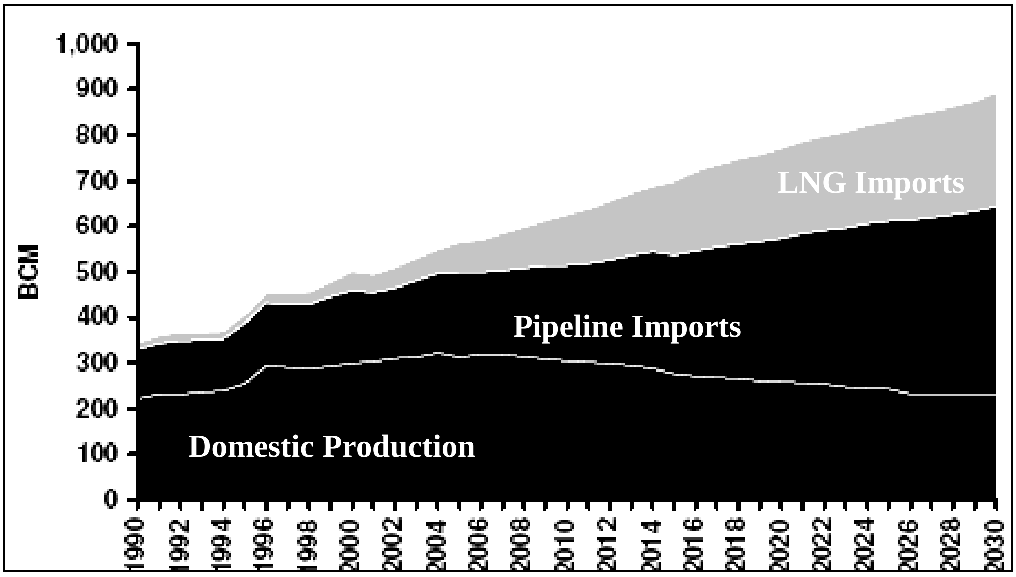
[245] Most times, terminal or capacity ownership is a pre-requisite for acquiring LNG cargoes and/or contracting liquefaction capacity. For instance, developers of the 7th NLNG train considered only prospective buyers with firmed up regasification capacity.
[246] Town Gas actually existed before 1965 in Europe but it is not covered here.
[247] Slochteren is the correct name of the field. Generally, it is called Groningen after the closest large town.
[248] Odell, Peter R; Oil and Gas: Crises and Controversies 1961-2000, Paragraph 1, Page 391, 2002.
[249] IEA; Security of Gas Supply in Open Markets: LNG & Power at a turning point, 2004.
[250] Stern, J. Competition and Liberalization in European Gas Markets, Paragraph 1, Page xv, 1998
[251] Also referred to as COMECON, CEMA and from 1991, Organization for International Economic Cooperation.
[252] Directive 98/30/EC of 1998 and its amendment: Directive 2003/55/EC of 2003.
[253] IEA; Security of Gas Supply in Open Markets: LNG & Power at a turning point, Paragraph 1, Page 288, 2004.

Directives, invariably, opened the gas industries to competition and liberalized access to pipeline networks.[254] These developments, ultimately, set the stage for the establishment of a uniform, liberalized natural gas market in Europe. This objective is yet to be achieved but LNG is increasingly playing a role (as Figure 2.12 indicates) in many gas markets within Europe.

Figure 2.12 Total European Gas Supplies[255]



Initially, as Table 2.4 shows, LNG was not very common in Europe. Since 2003, however, the number of LNG importers and proportion of LNG in gas consumption has been increasing – over 12% of Europe gas imports and 11.3% of European gas demand.

However, from Figure 2.13 below, it is apparent that only four of the LNG importers significantly determine European gas consumption - France, Italy, Spain and the United Kingdom. Apart from the size of their gas markets, these countries have been importing LNG from the 1960s.

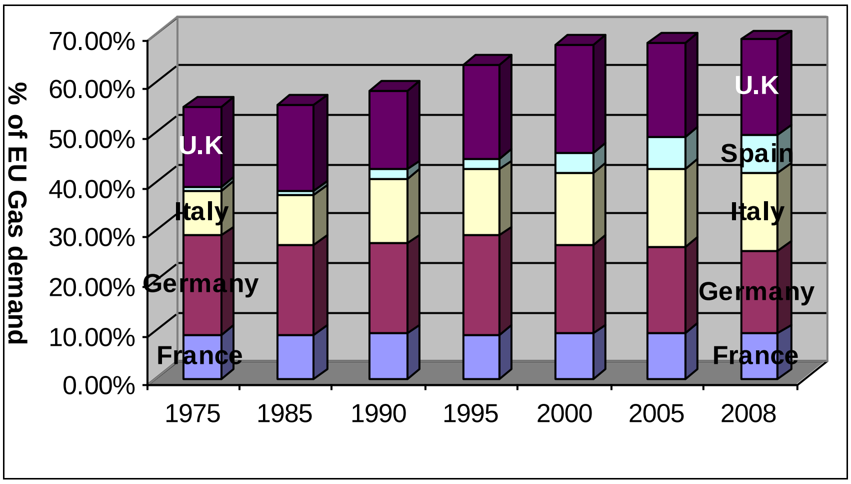
Table 2.4 Development of LNG imports into Europe (1995 to 2008)[256]

[254] Stern, J., Competition and Liberalization in European Gas Markets 1998

(1964-71)	(1995)[257]	% of LNG in Gas Demand	European LNG Importers in 2005	% of LNG in Gas imports	% of LNG in Gas Demand	European LNG Importers in 2008	% of LNG in Gas imports	% of LNG in Gas Demand
France	Belgium	40.3	Belgium	13.6	20.4	Belgium	12	14.6
Italy	France	21.6	France	26.2	28	France	25.6	28.5
Spain	Spain	82.6	Greece	16.1	15.5	Greece	22.7	22.3
U.K	Turkey	19.4	Italy	3.4	3.2	Italy	2.0	2.0
			Portugal	37.6	40.2	Portugal	57.7	57.3
			Spain	65.3	67.5	Spain	72.6	73.7
			Turkey	18.1	17.9	Turkey	14.1	14.7
			U.K	3.4	0.5	U.K	2.9	1.1
	Total	**5.4%**		**11.5%**	**9.7%**		**12.3%**	**11.3%**

Source: US EIA and BP Statistical Review

Figure 2.13 Top Five Gas Consumers in Europe[258]



Furthermore, their individual and collective contribution to European gas demand has been rising.[259] Given Table 2.4 and Figure 2.13, it is necessary to consider the positions of individual countries. So, their gas context is described below to show the history and relevance of LNG.[260] The following narrative also sets the scene for subsequent adoption of these countries in the simulation exercise.

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[255] http://www.berr.gov.uk/files/file41844.pdf
[256] Data extracted by author from US Energy Information Administration's World LNG Imports by Origin (1995-2005) and BP Statistical Review of World Energy (2006 and 2009 editions).
[257] These countries imported LNG during the period from 1993 to 1998. And by 2003, Greece and Portugal had become LNG importers.
[258] Data for this chart was extracted by author from BP Statistical Review of World Energy, 2009.
[259] Germany is one of the Top Five Gas consumers. However, it is yet an LNG importer and its proportion of EU Gas Demand has been declining.
[260] LNG has been and is important in Belgium's gas balance but it has been excluded from the analysis here. This because it is not among the top five gas consumers in Europe - the size of its market is relatively small.

2.2.2.1 France

The French gas industry developed through the production of town gas from coal in the 19th century. In 1939, natural gas was discovered and has been used mainly for heating. For a while, it remained a regulated industry dominated by a state-owned monopoly (GdF). The growth of domestic gas utilization, however, was interrupted by the shift to nuclear energy after the Arab oil embargo and subsequently the first oil shock in 1973. France owns the second-biggest integrated nuclear power infrastructure in the world. While the interconnection of nuclear plants generated most of the power, gas-fired plants contributed less than four percent of France's electricity supply in 2005.[261] Perhaps, this explains why France was slow to liberalize its gas sector.[262]

Table 2.5 Percentage of LNG in France's gas supply (1995-2008)[263]

Exporters	LNG Imports (% of Gas Supply) 1995	LNG Imports (% of Gas Supply) 2000	LNG Imports (% of Gas Supply) 2005	LNG Imports (% of Gas Supply) 2008
Algeria	21.62	26.11	16.36	17.19
Egypt	-	-	2.29	2.40
Libya	-	-	-	-
Nigeria	-	0.63	9.16	8.14
Qatar	-	0.20	-	-
Trinidad	-	-	-	0.18
Total[264]	**21.62%**	**26.94%**	**27.99%**	**28.48%**

Source: US EIA and BP Statistical Review

GdF and Elf Aquintaine[265]dominated the natural gas industry until 2004 when the markets were opened.[266] Its developmental pace notwithstanding, gas contributed about fifteen percent of France's primary energy supply in 2005. In the course of the gas industry's evolution, two LNG receiving terminals were built close to Marseille

[261] IEA, Natural Gas Market Review 2007 *Security in a Globalizing Market to 2015*, 2007.
[262] Trischmann, H., *LNG into Europe: European regulation – American style?* Issue 12, I.E.L.T.R. 2004.
[263] BP., Statistical Review of World Energy and Energy Information Administration, World LNG Imports by Origin.
[264] Only six main LNG exporters in the Atlantic Basin were considered here but, the **Total** dependence includes other exporters.
[265] Elf has now merged with Total to form Totalfina Elf.
[266] In 2002, the EU decided that gas markets should be opened fully for industrial consumers in 2004.

and Nantes between 1972 and 1980.[267] Since then, as evidenced in Table 2.5, the proportion of LNG in France's gas supply has been increasing.[268] Today, there are five hubs and over ninety-seven percent of its gas supply is imported. There are on-going plans to increase liquidity in the domestic gas market by merging three of the existing hubs[269] into one.

Besides, the energy regulator is disposed to more investments in LNG infrastructure. For instance, third party access (TPA) to GdF's regasification facility is not completely free even though it was Europe's largest LNG importer in 2002. Access requires the conclusion of a contract but the contracts are not easy to come by. In addition, "the duration of access to the LNG terminals is limited to one year, and the maximum duration per year for gas delivery to the transport network is set at 90 days, subject to the capacity".[270] Besides, access tariffs are set using a weighted average cost of capital (WACC) of 11% - to get a good return on capital and to boost new investments.[271] As a result of these incentives, other LNG importers (Exxon for example) are considering building their own terminals.

The above developments portend better opportunities for LNG in France. Obviously pipeline and LNG imports would increase as the new trading area (hub) is connected (by pipeline) to Montoir de Bretagne regasification terminal, as well as, the German and Belgian gas markets. A second regasification terminal at Fos Tonkin is also linked to the southern gas grid, while three other terminals have been earmarked for Dunkerque, Fos Cavaou and Antifer.

It has also been projected that, between 2004 and 2020, fifty-nine percent of incremental power demand would come from gas.[272] France's security of supply strategy is hinged on diversification of gas imports[273] as domestic production

[267] IEA, *Development of competitive gas trading in Continental Europe: How to achieve workable competition in European gas markets?* IEA Information Paper, 2008
[268] This implies increasing dependence on LNG exporters.
[269] The hubs are North H, West and East owned by the GRTgaz (subsidiary (TSO) of GdF).
[270] Dorigoni, S. and Portatadino, S., *LNG development across Europe: Infrastructure and regulatory analysis,* in Vol. 36, Energy Policy, 2008.
[271] *Ibid*
[272] IEA, Natural Gas Market Review 2007 *Security in a Globalizing Market to 2015*, 2007.
[273] Diversification, in terms of gas supply sources and routes (for pipeline gas) in line with EU energy policy.

declines. Despite its huge production of renewable energy,[274] perhaps France would continue to import LNG from Algeria, Egypt, Libya, Nigeria, Oman and Qatar.

2.2.2.2 Italy

The establishment of Agenzia Generale Italiana Petroli (AGIP) by the Italian government set the stage for mineral exploitation and subsequent discovery of natural gas in 1938.[275] As the Italian economy developed, state-owned companies drove further gas exploitation, while public utilities regulated prices and cross subsidies. With increasing demand in the 1970s, imports were needed and prices became more competitive. Later, following the EU's Gas Directives in 1998, the market was *fully* opened.

Gas is the second major source of energy (after oil) in Italy – contributed about thirty-five percent of primary energy consumption in 2005. Italy is the third largest consumer of natural gas in Europe and over ninety percent of residents have access to gas.[276] Due to the substitution of oil-fired plants with Combined Cycle Gas Turbine (CCGT) plants and shutting down of nuclear-power plants, gas has emerged the main source of power generation.[277] Initially vertically integrated and dominated by ENI, the gas industry is now part of the EU's effort towards competitive integrated energy markets. At present, the market is fragmented and there is room for players to earn monopoly rent.[278] So, Italy's gas market would not be described as efficient yet because there is room for improvement.[279]

An important fact about gas demand in Italy is that more than half of it occurs seasonally - during winter. Since 1970, Italy has relied on imports. Due to the decline in domestic gas exploration and production, its dependence on imports has risen substantially to over eighty percent of its gas supply.[280] Most of the imports have been through pipeline from Algeria and Russia but Italy has a regasification

[274] About ninety-eight percent of this comes from Biomass and Hydropower.
[275] IEA, *Development of competitive gas trading in Continental Europe: How to achieve workable competition in European gas markets?* IEA Information Paper, 2008
[276] Italy also has large storage capacity to support high demand during peak periods.
[277] Ninety percent of new plants will be gas fired.
[278] This situation is not peculiar to the Italian market.
[279] Cavaliere, A., *The Liberalization of Natural Gas Markets : Regulatory Reform and Competition Failures in Italy*, OIES publication, May 2007 at http://www.oxfordenergy.org/pdfs/NG20.pdf

terminal. The terminal is located in Panigaglia and it has been in operation since 1971. Meanwhile, its LNG imports from Nigeria are delivered at a French terminal[281] and swapped for pipeline gas from Algeria and Russia.

Table 2.6 Percentage of LNG in Italy's gas supply (1995-2008)[282]

Exporters	LNG Imports (% of Gas Supply) 1995	LNG Imports (% of Gas Supply) 2000	LNG Imports (% of Gas Supply) 2005	LNG Imports (% of Gas Supply) 2008
Algeria	-	4.35	3.16	1.56
Egypt	-	-	-	-
Libya	-	-	-	-
Nigeria	-	3.40	-	-
Qatar	-	0.06	-	-
Trinidad	-	-	-	-
Total[283]	**-**	**7.81**	**3.16%**	**2.01%**

Source: US EIA and BP Statistical Review

Describing Italy's gas situation, the International Energy Agency (IEA) asserts that "being a peninsula, gas connections and transit lines are limited compared to the size of the (Italian) market…and thus undermines the overall gas supply security".[284] Considering its constrained import infrastructure, Italy liberalized its gas sector to attract investments.[285] For LNG, Table 2.6 shows that the proportion of LNG in its gas supply has been decreasing. Perhaps, the six-year scheme of tariff incentives which was introduced to ensure higher returns on new LNG investments would change the trend.

The incentivized tariffs are generally higher than the EU's TPA stipulation. Through Article 27(2) of Law 273 of 2002 and Regulation Decision 90 of 2003, a temporary regime of priority access was granted to terminal owners for up to twenty years.[286] Also, the Development Law contains measures to simplify the permits procedure for

[280] *Ibid*
[281] Montoir-de-Bretagne regasification terminal.
[282] Extracted by the author from: BP., *Statistical Review of World Energy* and Energy Information Administration's *World LNG Imports by Origin*
[283] Only six major LNG exporters in the Atlantic Basin were considered here but, the **Total** dependence includes other exporters.
[284] IEA, *Development of competitive gas trading in Continental Europe: How to achieve workable competition in European gas markets?* IEA Information Paper, 2008
[285] The Executive Order ("Letta" Decree) No.164 of May 23, 2000 sets out the rules based on EC 1998/30 Gas Directive.
[286] Trischmann, H., *LNG into Europe: European regulation – American style?* Issue 12, I.E.L.T.R. 2004.

potential LNG projects.[287] The Law is part of an on-going strategy to generate fifty percent of Italy's electricity[288] from fossil fuels.

These issues present a window for LNG imports and explain why over ten[289] LNG liquefaction terminals have been proposed[290] despite the available storage facilities. Infact, applications for new LNG terminals increased since 2002 and many have been approved amidst internal and regional oppositions. Moreover, the priority access discussed above is now a national law in Italy.[291] Perhaps, in the coming years, increasing amount of LNG imports could be expected from Algeria, Egypt and Trinidad – existing LNG suppliers.

2.2.2.3 Spain

Gas consumption in Spain grew tremendously in the last fifteen years. But gas trading has remained tight due to low domestic production and lack of interconnecting pipeline to mainland Europe. In addition, its low storage capacity implies a heavy dependence on imported gas – by pipeline and as LNG. Initially, in 1973 Spain imported an insignificant amount of LNG but it now imports over 12% of global LNG imports.[292]

The trend of Spain's LNG imports over the last fifteen (in Table 2.7) is an indication of the growing dependence on LNG (exporters). With its six regasification terminals,[293] Spain has the most voluminous LNG industry and it is the largest importer in Europe. In fact, LNG has been and still is the primary source of gas.[294]

Table 2.7 Percentage of LNG in Spain's gas supply (1995-2008)[295]

	LNG Imports (% of Gas	LNG Imports (% of Gas	LNG Imports (% of Gas	LNG Imports (% of Gas

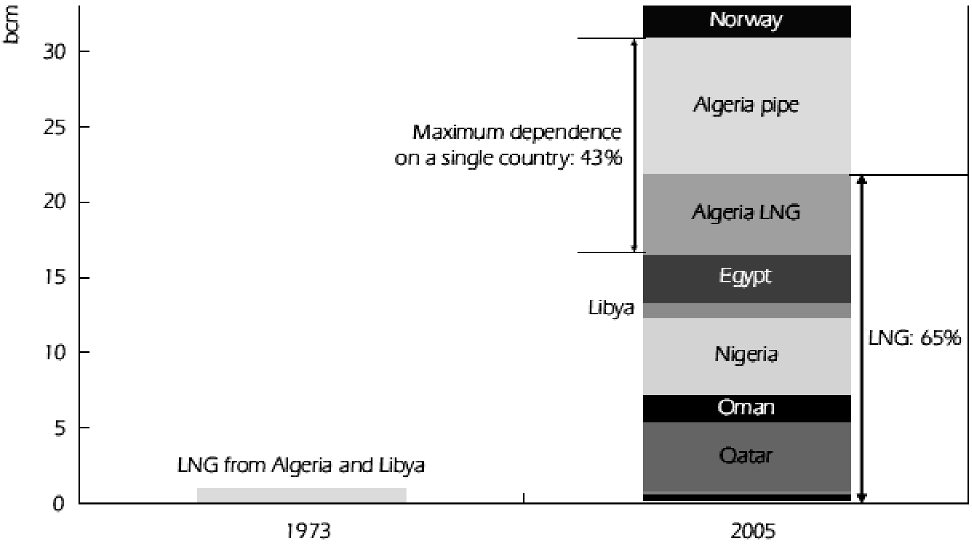
[287] Dow Jones Newswires, *Italy paves for Nukes, LNG,* in LNG Intelligence, 10th July, 2009.
[288] While nuclear and renewable sources would each power 25% of Italy's electricity supply.
[289] Two of them have received government approval.
[290] Stern, J., *Security of Supply: case study of European gas markets*, CEPMLP Lecture on March 6, 2006, in University of Dundee.
[291] It became a Law following the Marzano Decree approved on July 30, 2004.
[292] *See* **Table 2.2** "Top Five LNG Importers in the World" (year 2008)
[293] The terminals are located in Huelva; Cartagena; Barcelona; Sagunto; Ferrol and Bilbao.
[294] Therefore, LNG pricing looks more like the Pacific (based crude oil or HH) rather than Continental Europe (oil products). The history and nature of LNG pricing is described in Chapter Three.
[295] Extracted by the author from various editions of : BP., *Statistical Review of World Energy* and U.S Energy Information Administration's *World LNG Imports by Origin*

Exporters	Supply) 1995	Supply) 2000	Supply) 2005	Supply) 2008
Algeria	60.29	23.45	16.04	12.57
Egypt	-	-	10.91	12.60
Libya	15.39	4.59	2.69	1.36
Nigeria	-	9.98	15.45	19.17
Qatar	-	0.70	14.09	13.14
Trinidad	-	4.94	1.55	11.08
Total[296]	**82.55%**	**45.67%**	**66.79%**	**73.72%**

Source: US EIA and BP Statistical Review

So, any reduction in LNG supply would provoke severe adjustments in market dynamics and significant increase in LNG prices. This is especially because Spain depends a lot on Algeria (as Figure 2.14 shows) for its LNG and pipeline gas supply.

Figure 2.14 Spain's gas supply[297]



In realization of this and to ensure supply security, Spanish legislation stipulates that no more than 60% of overall national supplies can come from a single country. As such, LNG imports are now being diversified – initially from Algeria (mainly) and Libya, but now includes Egypt, Nigeria, Qatar and Trinidad.[298] Amongst other factors, the sustained increase in LNG imports could be attributed to the opening of Spain's gas market in 2003.[299]

[296] Only six main LNG exporters in the Atlantic Basin were considered here but, the **Total** dependence includes other exporters.
[297] IEA, Natural Gas Market Review 2007 *Security in a Globalizing Market to 2015*, 2007.
[298] Ball, J.R., and Drury, D., *Geopolitics of LNG*, p.164 in Griffin, P. and Smith, H. (Ed.), Liquefied Natural Gas: The Law and Business of LNG. (London: Globe Business Publishing Ltd; 2006).
[299] Full opening of the market was based on the Hydrocarbon Act 34/1998, as amended.

Meanwhile, the switch to gas-fired power generation also increased infrastructural investments. New storage and import facilities have been built or are on-going.[300] Although most of the new LNG import facilities were constructed to serve individual gas needs, they are not excluded from third party access. To protect and encourage investments, however, terminal owners are permitted to charge TPA tariffs with reasonable profit.[301] Furthermore, there is a TPA 'use it or lose it' capacity requirement to discourage speculative reservation of capacity. In this regard, each third party application for access requires a financial bond for the first year of the resultant contract.[302]

This regulatory framework was designed to ensure competition downstream. In spite of the Spanish government's efforts, however, GN-Endesa still dominates Spain's gas sector. Infact GN-Endesa - Europe's fourth largest energy utility[303] – is the main LNG importer in Spain's domestic wholesale gas market. With the start-up of the Sagunto Terminal[304] expectations are that LNG imports and competition would increase. A relevant question, therefore, is whether Spain would potentially face more competition from other LNG importers in the Atlantic Basin.

2.2.2.4 United Kingdom

In the UK, like France and Italy, gas was manufactured from coal and used for cooking in the early 20th century. But unlike its neighbours, the UK lacked domestic supply to satisfy rising demand during the industrial revolution. Subsequently, LNG became an option suggested by Shell. Before the first commercial cargo of LNG arrived in 1964, a pipeline had been built from Canvey Island to Leeds – connecting other parts of the United Kingdom.

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[300] 300,000m^3 Sagunto Terminal; 150,000m^3 Huelva Terminal; Two 150,000m^3 plants at Ferrol Terminal and another 150,000m^3 at Barcelona.

[301] Trischmann, H., *LNG into Europe: European regulation – American style?* Issue 12, I.E.L.T.R. 2004.

[302] In the event that the third party uses less than 80% (on average) of its contracted regasification capacity in the initial six months of the contract, the bond is liquidated *pro rata* by the facility owner automatically. This, however, does deny the third party the right to permanently reduce its contracted capacity if it chooses to do so during the contract year.

[303] It follows after *Electricity de France (EdF)*; German *E. Onand* and Italy's *Eni*.

[304] On the Costa del Azhar in the Mediterranean. For more on this, see Energy Intelligence, *Sagunto keeps Spanish LNG growing*, p.5, World Gas Intelligence, Vol. XVII, No.7, February 15, 2006.

So, Algerian gas supplied eight regions of the UK until 1967 when natural gas was discovered and produced in the North Sea.[305] A domestic gas network was then built to encourage industrial utilization of gas – setting the stage for a gas market. Therefore, UK's gas demand grew rapidly, from 5.4% in 1970, to become the dominant fuel in the country's total energy mix.[306] United Kingdom is Europe's largest gas consumer[307] - about 20% of EU total and around 3% of global total. However, a third of UK's gas demand is being met by imports and could rise to eighty percent (60% by pipeline and 20% as LNG)[308] by 2020.[309] Pipeline import capacity is about one-fifth of demand[310] and its storage capacity is only 4% of annual consumption.[311]

Even after completing the ongoing ten onshore storage projects, the UK could still fall below the EU norm of 14% coverage.[312] The UK's supply situation is a consequence of the quicker-than-expected declines in North Sea gas production and its interconnection with the less liquid Continental European market. Perhaps, some degree of market failure contributed to previous supply gaps in the UK gas market. For instance, between 2006 winter and 2007, the UK absorbed surplus gas from Continental Europe at a higher[313] price. Such market failure could possibly create similar gaps in future, but the UK's regulatory framework for gas still ensures a high degree of transparency and liquidity.

The situation described above explains the trend depicted in Table 2.8 and portends an optimistic future for LNG imports. Until recently, the UK did not participate actively in Atlantic Basin (AB) LNG trade. But, between 2004 and 2007, there was significant addition to pipeline and LNG import capacity – 131mcm per

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305 IEA, *Development of competitive gas trading in Continental Europe: How to achieve workable competition in European gas markets?* IEA Information Paper, 2008
306 Wright, P. Gas Prices in the UK, p.1, paragraph 2, (2006)
307 British gas supplies are also used to satisfy demand in Northern Ireland and Ireland.
308 Pipeline gas is expected from Norway; Continental Europe and Russia. LNG is expected from Algeria; Egypt; Nigeria (mainly spot); Qatar and Trinidad.
309 Department of Energy and Climate Change (DECC) Energy Markets Outlook 2008
310 Wright, P. Gas Prices in the UK, p.13, paragraph 1, (2006)
311 The UK's gas storage capacity is one of the lowest in Europe.
312 Shook, B, *Storage-challenged UK looks to adopt US Salt Cavern expertise*, p.5, Natural Gas Week, February 6, 2006.
313 Relative to NBP - an index for Spot LNG

day (about 50% of the UK's consumption).[314] As such, the UK's dependence on LNG doubled from 2005 to 2008. Furthermore, the regulatory changes have been undertaken to encourage diversification through LNG.[315]

Table 2.8 Percentage of LNG in the UK's gas supply (1995-2008)

Exporters	LNG Imports (% of Gas Supply) 1995	LNG Imports (% of Gas Supply) 2000	LNG Imports (% of Gas Supply) 2005	LNG Imports (% of Gas Supply) 2008
Algeria	-	-	0.48	0.39
Egypt	-	-	-	0.09
Libya	-	-	-	-
Nigeria	-	-	-	-
Qatar	-	-	-	0.13
Trinidad	-	-	0.07	0.50
Total[316]	**-**	**-**	**0.55%**	**1.11%**

Source: US EIA and BP Statistical Review

So far, anyone seeking access to an LNG facility is required to apply for it with relevant details. Subsequently, negotiations would be undertaken towards achieving a bilateral access agreement.[317] However, the UK's gas market legislation[318] also empowers OFGEM to entertain and grant requests for exempting LNG terminals from granting TPA.[319] The willingness of LNG terminal developers to invest in the UK[320] has, therefore, been attributed to the application of such TPA exemptions.[321] At present there are two regasification terminals[322] in operation within the UK but the number is set to increase from on-going/approved projects.[323] Considering difference in market size, it is noteworthy that the regime is similar to that of the US,

[314] IEA, Natural Gas Market Review 2007 *Security in a Globalizing Market to 2015*, 2007.
[315] This is line with EU policy and obvious in Table 2.8.
[316] Only six main LNG exporters in the Atlantic Basin were considered here but, the **Total** dependence includes other exporters.
[317] The regulator (Office of Gas and Electricity Markets – OFGEM) may intervene, if negotiations are considered discriminatory and not in good faith, by requesting for an auction of regasification capacity.
[318] That is the Gas Act 1986 as amended through the Gas (Third Party Access and Accounts) Regulations 2000 (SI 2000/1937).
[319] Trischmann, H., *LNG into Europe: European regulation – American style?* Issue 12, I.E.L.T.R. 2004.
[320] While only a few investments have been undertaken, the number of terminals is still significant considering the UK's gas resources and interconnection with Continental Europe.
[321] Moen, K., *The Gas Directive and Third Party Transportation Rights – What Pipeline Volumes are available?* p.50, Vol.21 No.1 Journal of Energy and Natural Resources Law, 2003
[322] They are Isle of Grain (Grain LNG) and South Hook terminals.
[323] Dragon LNG import terminal as located in South Hook is almost ready for commissioning.

Italy, Belgium and Spain.[324] Nevertheless, it is important to note that LNG is still a small part of the UK's gas supply.

Concluding Remarks

In some of the countries reviewed above, LNG is an important part of the gas market and may become more important in all of them. So, new opportunities exist for LNG in Atlantic Basin natural gas markets. But, increased reliance on imports could expose these markets to shocks in international LNG trade. For instance, some countries[325] may have to show greater willingness to secure gas by paying more or encouraging investments. In the present context of global recession (low energy demand), one wonders whether some of the projections about LNG are likely to change. If so, will it affect the LNG trade and how? Few projections have been reviewed downward but, it is too early to speculate on the potential implications for LNG trade. Besides, the main determinants of LNG demand[326] are also simultaneously being distorted as markets adjust, interact and re-adjust.

A pertinent question worth considering is whether LNG exporters would compete for markets within and outside the Atlantic Basin. If not, with supply diversification and competitive energy markets, a larger part of the rent would be available for the taking. But will this create an incentive for market control or defense of price - through a uniform pricing arrangement? A continuous re-assessment of price incentives by LNG exporters seems the logical expectation in all circumstances. In this context, how do the exporting countries stand?

2.3 Exporting Countries

A cursory look at Table 2.9 reveals that there are few Atlantic Basin LNG exporters today but by 2015 liquefaction capacity would increase. For the purpose of manageability, precision in the simulation and thorough analysis, it becomes

[324] These countries have the highest number of regasification terminals in the Atlantic Basin.
[325] Given that each North American/European consuming country has its specific energy needs and priorities. Besides the EU's 1998 Energy Markets Directive allows member states to adopt individual provisions to fit their peculiar circumstances.
[326] Crude oil price; pipeline gas prices and demand; electricity prices; prices of coal and emission permits, as well as, available liquefaction capacity are the principal determinants of LNG price.

necessary to narrow down the number of countries. To achieve this purpose, three simple criteria are applied, within the timeframe of the book, using Table 2.9:

- Extent of current participation in the market[327]:

Based on LNG export capacity, the top five countries (2005 to 2010) were chosen – Algeria, Egypt, Nigeria, Qatar and Trinidad;

Table 2.9 Atlantic Basin liquefaction capacity and gas reserve[328]

Country	Past	Future (mtpa)	Share of global LNG exports (%)	Share of global proven gas reserves (%)
	2008[329]	2015	2007[330]	1st Jan '08[331]
Algeria	20.23	25.7	10.9	2.6
Egypt	12.20	21.8	6.01	0.9
Libya	0.7	0.7	0.34	0.8
Eql. Guinea	0.0	3.4	0.63	0.1
Nigeria	21.70	71.8	9.35	3.0
Norway	4.3	4.3	0.06	1.3
Trinidad	15.1	20.0	8.02	0.3
Angola	0.0	5.0	-	0.1
Venezuela	0.0	4.7	-	2.7
Russia (West)	0.0	30.0	-	27.2
Atlantic Basin	**74.23**	**157.4**	**52.31**	
Qatar[332]	30.6	77.0	17.0	14.6
Grand Total	**104.83**	**234.4**	**-**	**-**
Research Total	**-**	**-**	**51.62**	**22.2**

Source: Gas Strategies

- Potential ability to participate in the market:

Based on proven gas reserves and potential liquefaction capacity (by 2013) the top five exporting countries were chosen – Nigeria, Algeria, Egypt, Qatar and

[327] The top-five countries jointly exported 51.62% of global LNG trade in 2007.
[328] Extracted by author from Gas Strategies Database (www.GasStrategiesOnline.com)
[329] Data for Algeria; Egypt; Nigeria; Trinidad; Qatar and Norway were extracted from GIIGNL, *The LNG industry*, 2008. Expected capacity expansion is the difference between the capacity in 2008 and 2015.
[330] The 2007 figures for "Total LNG exports" were extracted from Wagbara, O., *What are the prospects for a gas OPEC*, in International Gas, October 2008.
[331] EIA, *International Energy Outlook 2008*, at http://www.eia.doe.gov/oiaf/ieo/
[332] Other Middle East gas-rich countries were excluded from this table because they are either non-LNG exporters or export less than one percent of the global sum.

Trinidad.[333] Although Russia has the highest gas production and proven gas reserves it is excluded because it is unlikely to become a major LNG exporter by 2013.[334]

- Regional representation

Finally, in addition to the above criteria, effort was made to include one small/new LNG exporting country and one country from each LNG producing region - North Africa, West Africa, Americas and Middle East. As a small LNG exporter, only Libya met the initial pre-requisite conditions, alongside Algeria, Egypt, Nigeria, Qatar and Trinidad – which are also representing their respective producing regions.

So, before modeling, the subsequent part of this chapter describes each country's trade pattern - export market, as well as, existing and potential[335] export capacity. The theoretical basis for the description is that a country's ability to exploit its gas resources depends on the available markets; price(s), in addition to its domestic energy needs and policy.[336]

2.3.1 Algeria

Atlantic Basin LNG trade, as stated earlier, was pioneered in 1964 by Algeria's first commercial LNG delivery (from the Arzew GL4Z plant) to Canvey Island UK.[337] Algeria dominated the LNG trade in the Atlantic Basin for almost fifteen years until a price dispute with the US in the late 1970s. By early 1980s Algerian exports to the US were suspended and subsequently Algeria was squeezed out of North America by Trinidad and Tobago in 1999. But, in those years, Algeria had also developed LNG trade relations with France, Turkey and Italy.[338]

This North African country is now the largest exporter of LNG to Europe and the fourth largest producer of LNG in the world (Table 2.10 shows new and renewed contracts). With a liquefaction capacity[339] of 26.2Bnm^3, Algeria accounted for 10.9%

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333 The five top countries accounted for over one-fifth of the world's proven gas reserves in 2008.
334 Additional discourse on Russia has been included in section 2.4 below.
335 Possible completion date of 2013
336 Section 2.2 highlights demand context, pricing issues are addressed in Chapter Three.
337 EIA, Country Analysis Briefs – Algeria, at http://www.eia.doe.gov/emeu/cabs/Algeria/NaturalGas.html
338 Apart from consolidating trade with United Kingdom - before gas was discovered at the North Sea.
339 Petroleum Economist March 2007.

of global LNG exports in 2007.[340] It extended its market share by constructing two other important export terminals at Skikda and Algiers, while another train is being added to the Arzew Plant. Algeria now exports LNG to more countries – including Belgium, Greece, Portugal, Spain and the Unites States.

Table 2.10 Algeria's LNG Contract Obligation[341]

Export to	Nominal Qtty[342] (mtpa)	Duration	Form
France	1.3	1992 - 2013	F.O.B
"	2.5	1972 - 2019	F.O.B
"	3.7	1976 - 2013	F.O.B
Greece	0.5	2000 - 2021	F.O.B
Italy	1.40	1997 - 2014	F.O.B
"	0.86	1999 - 2022	D.E.S
Spain	0.75	2002 - 2017	D.E.S
"	0.45	2002 -	D.E.S
"	1.15	2002 - 2021	D.E.S
"	0.92	2002 -	
Turkey	3.0	1994 – 2014	D.E.S
U.S.A	3.2	1989 – 2009	

Source: GIIGNL

Downstream, Algeria's Sonatrach[343] has some capacity at the UK's Isle of Grain regasification plant, and also participates in other European gas and electricity markets.[344] In total,[345] Algeria accounted for twelve percent of EU's gas imports (second to the FSU) in 2007.[346] Algeria attained this height by exporting gas through pipeline as well. Its pipeline gas exports to Europe started in 1983[347] and could reach 60bcm per annum by 2010. Considering Table 2.10, some pertinent questions come to mind. Is Algeria likely to meet its present and future contractual obligations for LNG and pipeline gas? Moreover, one wonders where its priority would be – pipeline or LNG.[348] Conceivably, both options offer Algeria a strategic

[340] BP, Statistical Review of World Energy, 2008.
[341] GIIGNL, *The LNG industry*, 2008.
[342] Annual Contracted Quantity
[343] Sonatrach is Algeria's National Gas Company.
[344] Sonatrach does this through MOUs, subsidiaries and/or partnerships in Spain, France and Portugal.
[345] Pipeline gas and LNG combined.
[346] Cedigaz, *2007 Natural Gas Year in Review*, Press Release, May 7, 2008
[347] Through the Trans-Mediterranean (Transmed) pipeline.
[348] At present Algeria exports a fairly equal amount of LNG and pipeline gas to Europe.

advantage in its bid to earn more gas revenue. Perhaps, this explains Algeria's interest in the Trans-Sahara Gas Pipeline[349] – an alternative source of gas supply.

Meanwhile, Algeria has a fairly robust domestic grid, built around major gas fields, that enables widespread gas utilization. Natural gas provided sixty-four percent of the primary energy supply in 2006. One reason for this high consumption is the inefficient price levels (fixed in the 1970s and 1980s). At the current rate of domestic consumption and exports, Algeria's proven reserves could run out after fifty years.[350] However, due to the high and increasing rate of gas exploitation, some Algerians are arguing for a drastic cut in exports. In 2007, for instance, Algeria's exports to Europe decreased by six percent.[351] Therefore, in an effort to lessen domestic burden on exports, the government is encouraging exploratory[352] efforts by foreign investors.

2.3.2 Egypt

Egypt began the liquefaction of natural gas in 2004 from its single-train Damietta LNG plant. The following year, a second liquefaction plant at Idku also began exporting LNG.[353] Egypt now has a liquefaction capacity of 12.2MTPA and exports about 6.01% of global LNG[354] to France, Italy Spain, and the US. Between 2007 and 2008, gas exports generated revenue of about USD3.3billion for Egypt.[355]

Considering the existing contract obligations (shown in Table 2.11), it is obvious that Egypt expects to earn increasingly more revenue from LNG. Besides, its clientele is expanding beyond the Atlantic Basin and some existing liquefaction plants have been earmarked for expansion. But, gas supply is uncertain and there is an existing moratorium – in June 2008, government suspended the initiation of new gas export contracts till 2010. One reason for this is that gas demand in Egypt

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[349] Through the TSGP Nigerian supply would feed Algeria's grid or LNG for subsequent export to Europe.
[350] BP Statistical Review of World Energy, June 2007.
[351] Cedigaz, *2007 Natural Gas Year in Review*, Press Release, May 7, 2008
[352] Gas production and wholesale distribution is dominated by Sonatrach.
[353] IEA, Natural Gas Market Review 2007 *Security in a Globalising Market to 2015*, 2007.
[354] Stern, J., *Gas as a Transitional Fuel*, Table 1, OEF, February 2008.
[355] EIA, Country Analysis Briefs – Egypt, at http://www.eia.doe.gov/emeu/cabs/Egypt/NaturalGas.html

is seventy percent of domestic production.[356] Given the large amount of gas consumed,[357] policy makers are concerned that Egypt's proven gas reserves[358] - 0.9% of global total – would not sustain its economic development.[359] At the current rate of production and consumption, the reserves could be exhausted after forty years.[360] As such, Egypt would need more gas discoveries and production infrastructure to sufficiently meet export obligation.

Table 2.11 Egypt's LNG Contract Obligation

Exporting Company	Importer	Country	Volume (mtpa)	Volume (Bcm)	Start	End
Egypt LNG Train 1	Gaz de France	France[361]	3.60	4.93	2005	2025
Egypt LNG Train 2	BG	USA/Italy	3.60	4.93	2006	2026
SEGAS	Union Fenosa	Spain	2.41	3.30[362]	2004	2025
SEGAS	BG[363]		0.76	1.04	2005	2011
SEGAS	Petronas(ALTCO)		0.76	1.04	2005	2011
SEGAS	BP		1.06	1.45	2005	2025
Egypt Total			**12.19**	**16.70**		

Source: Gas Strategies

However, Egypt's gas policy stipulates that a third of every gas discovery would be used domestically; another third to be kept for future generation and a final third be applied to export. Meanwhile, policymakers announced on-going efforts towards nuclear power generation[364] to ease the pressure of domestic gas consumption on exports.[365]

356 Three sectors – Petrochemicals; Power generation and Manufacturing – account for over eighty-five percent of this.
357 Both domestically and in the export markets.
358 This is in addition to other fossil fuels.
359 Egypt has a population of Eighty Million and the World Bank estimates it has a 7% annual growth rate.
360 BP Statistical Review of World Energy, June 2007.
361 Contract is destination flexible. Cargoes could supply both France and other markets in Continental Europe.
362 Volume increased to 4Bn cubic metres per year from 2009.
363 BG and Petronas will take approx. 2.1 Bcm until 2008 and approximately 1.4 Bcm until 2011 (on equal proportions). Both upstream partner companies are in negotiations to extend the contract for 1.4 Bcm beyond 2011.
364 Alhajji, A., *Oil and Gas in the Capitals*, in Vol. 228, No.12, World Oil, 2007

2.3.3 Libya

Libya became the second LNG exporter in the world when, in 1971, it delivered long term contracted cargoes respectively to Snam and Enagas of Italy and Spain. With an initial liquefaction capacity of 2.3mtpa at the Marsa el Brega plant, Libya's LNG industry has not developed any further. It went through a series of price disputes[366] with customers and since 1981 the country's export capacity has remained less than 1.15mtpa. There are, however, on-going plans to enhance the efficiency and capacity of the old plant. At present, most LNG exports go to Spain[367] but it is expected that additional capacity would be sold to Italy and Turkey after the plant's upgrade.

Gas consumption in the economy is less than one-third of primary energy demand.[368] At the current level of exports and domestic demand, Libya's gas reserves could last for another eighty-five years.[369] Meanwhile, with the lifting of United Nations sanctions, the Libyan government has taken several institutional and fiscal steps to attract investments towards exploring and exploiting gas deposits – about 1.32trillion cubic meters.[370] In 2004, for instance, Libya made its petroleum fiscal regime more attractive[371] for investments in gas exploration and production. Meanwhile, it also signed a Memorandum of Cooperation with Russia's Gazprom in 2008. These efforts are aimed at encouraging gas production and utilization by households and petrochemical companies, as well as, exports.

But, like Algeria, Libya also has a conflict between furthering pipeline gas or LNG exports. With the completion of the *Greenstream* pipeline in 2004, for instance, exports from Melitah to Europe[372] have increased substantially.[373]Aside from

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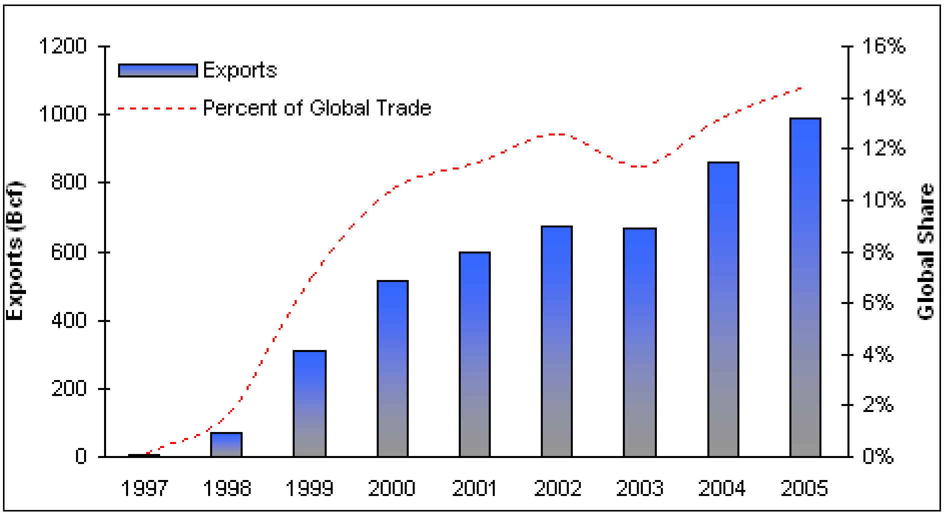
[365] Approval has been given for building a network of 1gigawatts nuclear generating plants.
[366] Price disputes occurred between 1969 and 1971 (which delayed exports), as well as, in 1979 (due to a unilateral change in price regime).
[367] The existing contract was signed with Gas Natural in 1971.
[368] US EIA., *International Energy Annual 2005*, at http://www.eia.doe.gov/iea/
[369] It is, however, very low – less than one percent of world total.
[370] BP Statistical Review of World Energy, June 2007.
[371] When compared to the exiting contractual terms for petroleum activities. Kemp, A., and Otman, W., *The Petroleum Development Investment Risks and Returns in Libya: a Monte Carlo Study of the Current Contractual Terms (EPSA IV)*, North Sea Occasional Paper, Aberdeen, Scotland.
[372] The gas is delivered into Italy and further down to mainland Europe from Sicily.
[373] http://www.eia.doe.gov/emeu/cabs/Libya/NaturalGas.html

exports to Europe, Libya has been considering several regional initiatives with Tunisia, on the one hand, as well as, with Algeria and Egypt.[374] For instance, an agreement was signed in 1997 for a pipeline that would link Libya to the Egyptian gas grid. One then wonders the basis on which the various projects would be prioritized.

2.3.4 Qatar

Until 1997 Qatar was not an LNG exporter, but it started small[375], grew rapidly (see Figure 2.17) and has become the number one LNG exporter in the world.[376] In 2005, Qatar exported 1 trillion cubic feet of LNG, but with on-going projects,[377] it could provide more than half of all new LNG supply globally[378] - 77million metric tons of LNG.[379]

Figure 2.17 Growth of Qatar's LNG Exports[380]



So far, Qatar's LNG companies (Qatargas and Rasgas)[381] export LNG to Italy, Mexico, Spain, United Kingdom, and United States, in the Atlantic Basin. Like

[374] Unfortunately, some of these efforts have been under consideration since 1997.
[375] About 120,000 metric tons of LNG was first delivered to Spain in 1997.
[376] Qatar could remain the leading LNG exporter for years to come.
[377] Additional trains being added to RasGas and Qatargas are expected to be completed between 2010 and 2015.
[378] Energy Intelligence Group, *Report predicts a radical change in LNG equation*, LNG Intelligence, Thursday, February 15, 2007.
[379] EIA, *International Energy Outlook 2008*, at http://www.eia.doe.gov/oiaf/ieo/pdf/nat_gas.pdf
[380] Source: EIA natural Gas Monthly (Aug. 2006); IEA natural Gas information 2006, at http://www.eia.doe.gov/emeu/cabs/Qatar/NaturalGas.html

Algeria's Sonatrach, Qatar Petroleum owns regasification capacity in the Golden Pass Terminal (US Gulf Coast) and South Hook in the UK. In their strategic effort to earn more revenue, Qatar plays along the LNG value chain. For instance, through Qatar Gas Transport (Nakilat)[382] a 215,000m^3-capacity vessel has been acquired. Furthermore, it aims to focus on petrochemical projects, in addition to regional gas pipeline projects.

Table 2.12 Qatar's LNG Contract Obligation[383]

Export to	Nominal Qtty[384] (mtpa)	Duration	Form
Belgium	2.05	2007 – 2027	D.E.S
India	7.5	2004 - 2028	
Japan "	4.0 2.0	1997 - 2021 1998 – 2021	D.E.S D.E.S
Korea "	4.92 2.10	1999 - 2024 2007 - 2026	F.O.B D.E.S
Spain " " " " "	0.66 0.66 0.75 0.88 0.75 0.74	2001 - 2012 2002 – 2012 2005 – 2025 2003 – 2022 2004 – 2023 2005 – 2025	D.E.S " " " " "
EU	0.75	2006 – 2025	F.O.B
Taiwan	3.08	2008 – 2032	F.O.B

Source: GIIGNL

Meanwhile, domestic gas consumption is high – eighty percent of primary energy demand[385] - due to power demand. Qatar's subsidized price regime is responsible for rising gas consumption[386] even as its reserve declined by one percent (5 trillion cubic feet) in 2007.[387] Although, it has the third largest gas reserve,[388] a moratorium has been placed on new LNG projects following a reserve integrity test. Qatar's equidistance from the three major regional gas markets is notable. A more

[381] Both dominate Qatar's LNG sector and are owned part by Qatar Petroleum (QP). QP, which could be described as the National Petroleum Company, is the main upstream producer of natural gas and vital player in downstream projects.
[382] *Nakilat* is the shipping company responsible for transporting Qatar's LNG. It also represents Qatari midstream interest in the LNG chain.
[383] GIIGNL; *The LNG industry*, 2008.
[384] Annual Contracted Quantity
[385] BP Statistical Review of World Energy, June 2007.
[386] Stern, J., *Gas as a Transitional Fuel*, Table 1, OEF, February 2008.
[387] EIA, *International Energy Outlook 2008*, at http://www.eia.doe.gov/oiaf/ieo/pdf/nat_gas.pdf

interesting issue, however, is to reconcile the moratorium with Qatar's existing contracts (detailed in Table 2.12). Moreover, it concluded another set of contracts in 2008 - to supply UAE; China (Petrochina and Shell 3mtpa each for 25years) and Kogas 1.3mtpa for 8years.

A closer look at the contracts reveals that over the next few years Qatar has contracted to export 7.24mtpa and 30.09tpa respectively to the Atlantic Basin and Asia Pacific region[389]. In spite of Qatar's geographical proximity to most LNG importers, it would be interesting to see how it satisfies domestic, regional and other supply obligations.[390] Satisfying domestic and regional gas demand may seem a higher priority but LNG remains a vital source of revenue.

2.3.5 Nigeria

Domestic gas consumption in Nigeria was mainly in the form Liquefied Petroleum Gas. Although crude oil was discovered in Nigeria in 1957, its associated product gas was not commercialised but flared or re-injected for enhanced oil recovery. However, Nigeria staggered into the LNG market. The idea of Nigeria LNG (NLNG) was first proposed in 1965[391] but nothing happened[392] till 1989 when the company was incorporated. Between 1965 and 1989, a combination of internal socio-political variables constrained the export of Nigeria's gas resources. Principal amongst them was the exploitation of oil; resource curse from large amount of oil revenues and political crisis.

Politically, after a civil war that lasted for over three years,[393] Nigeria encountered two military coups before a civilian government was elected in 1983. As such political instability and corruption resulted in protracted[394] contract negotiations till another military regime replaced the civilian administration - led by Alhajji Shehu

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[388] As of January 1, 2008 Qatar's proven reserve was 905 trillion cubic feet (14.6% of the global total) according to EIA, *International Energy Outlook 2008.*

[389] Included in this classification are China, India, Japan, Korea and Taiwan.

[390] And simultaneously undertake seasonal price arbitrage when the opportunity arises.

[391] Asiodu, P., *Developing and supporting critical energy infrastructure for Vision 2020: Challenges, Constraints and Prospects*, in IAEE Energy Forum, Fourth Quarter, 2008.

[392] There were many missed opportunities but the dream staggered on.

[393] Nigeria's civil war lasted from 1966 to 1970.

[394] Even after 1989, some of such issues lingered on and later became a subject of parliamentary inquiry. For more details see http://www.halliburtonwatch.org/news/nigeria_parliament_report.pdf

Shagari – in 1983. These political events culminated in the lack of rule of law and poor governance. Besides, Nigeria had no effective Gas Policy and so NLNG could not stand in a vacuum. Apart from the geopolitical constraints and high country risk,[395] Shell's plan was also hindered by lack of loans to finance the project.[396]

Table 2.13 Nigeria's LNG Contract Commitment[397]

bn cm/y	Volume
Trains 1/2 (first exports: Oct 99)	
Enel (Italy)	3.50
Gas Natural (Spain)	1.60
Botas (Turkey)	1.20
Gaz de France (France)	0.50
Transgás (Portugal)	0.42
Total	7.22
Train 3 (first exports: Nov 02)	
Gas Natural (Spain)	2.70
Transgás (Portugal)	1.00
Total	3.70
Trains 4/5 (first exports: Jan 06)	
BG	3.00
Transgás (Portugal)	2.00
Eni (Italy)	1.50
Shell	1.50
Iberdrola (Spain)	0.50
Total	0.30
Total	8.80
Train 6 (first exports due: Jan 08)	
Shell	4.20
Total	1.40
Total	5.60
Grand total	25.32

* Spot sales are additional.
Compiled from company information and *Petroleum Economist* estimates.

Faced with such insurmountable obstacles, Shell and other co-sponsors[398] opted to provide funds for the project and boldly took the Final Investment Decision in 1995. The project suffered huge cost over run but within four years production had begun (in 1999) and the first NLNG cargo was exported to Italy.[399] While the initial effort lingered for several years without LNG, it is remarkable that within seven years of first production, six trains (see Table 2.13) were built and commissioned. Worth noting is the fact NLNG as a project-company[400] and its partners were granted attractive fiscal incentives and unusual exemptions.[401] Now Nigeria has the second

395 Human rights were violated and Nigeria was defaulting in its international credit obligation.
396 While the World Bank called for reforms and advised cautious lending, most International Financial Institutions refused to provide finance for the project.
397 Petroleum Economist, January 2008.
398 They were Agip and TotalFinaElf.
399 NLNG, *The Company: Milestones* at http://www.nigerialng.com/NLNGnew/companyinfo/Milestones.htm
400 Sometimes termed Special Purpose Vehicle (SPV) created for the project - liquefaction and sale of gas.
401 This included, but not limited to, 10-year tax relief; withholding tax exemptions; capital allowances; and untaxed dividends with ease of repatriation.

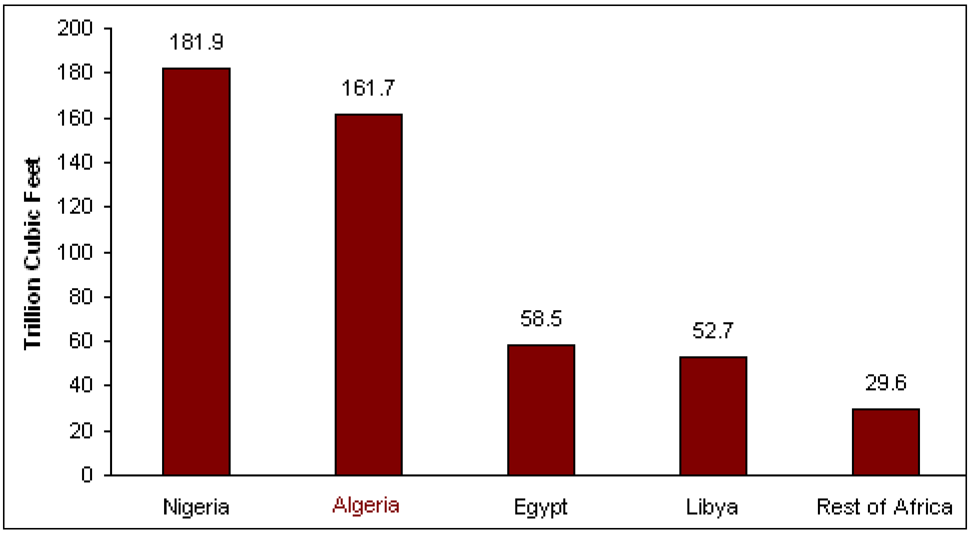
fastest growing liquefaction capacity in the globe and sells LNG to France, Italy, Spain, United Kingdom and US.

In 2007, Nigeria exported 3.5 metric tonnes of Natural Gas Liquids (NGLs) and 22 metric tonnes of LNG. At present, there are three on-going (but uncertain) LNG projects aimed at enhancing Nigeria's position as a major LNG exporter (especially in the Atlantic Basin). The projects are Train 7 of NLNG; Brass LNG and Olokola LNG (OKLNG).[402] To further assert itself across the LNG market, the Nigerian National Petroleum Corporation (NNPC) and three other companies[403] established a company - Nikorma Shipping Services - to provide LNG transportation services.[404]This is an achievement because of Nigeria's preference for selling LNG destination ex-ship (D.E.S),[405] as well as, its interest in price arbitrage.

Domestically, the proportion of gas consumption in the energy mix is very low[406] due to lack of infrastructure and investments. To reverse this situation, the Yar' Adua-Jonathan Administration proposed a framework for pricing and domestic supply obligation (DSO)[407]. In addition, domestic gas supply has been prioritized in the government's double-edged gas utilization strategy. So far, fifteen companies[408] have been chosen to participate in the new gas utilization agenda, while 2011 is another deadline for ending gas flaring. Nigeria has the largest proven gas reserve in Africa (as Figure 2.18 shows), but the achievement of the above policy objectives remains uncertain.

Figure 2.18 Top Gas Reserve Holders in Africa (2007)[409]

[402] Brass LNG is expected to have two trains with a capacity of 10mtpa. It is jointly owned by NNPC, ENI, Conocco Phillips and Total. OKLNG, owned by NNPC, Shell, Chevron and BG, is a four-train 20mtpa project.
[403] They include Malaysia International Shipping Company (MISC); Deep Water Shipping Company and Hyundai Heavy Industries (HHI).
[404] Alexander Oil and Gas Connections; volume 13, issue No. 3 - Friday, February 15, 2008
[405] Most of Nigeria's newly signed contracts are D.E.S.
[406] Relative to oil; flared associated gas and proven gas reserves. According to the EIA's *International Energy Annual 2005,* gas contributed only thirty-six percent of Nigeria's Primary Energy Demand in 2005.
[407] This DSO mandates upstream petroleum operators in the country to set aside a predetermined amount of their gas production (and reserves) for the domestic gas (and power) market.
[408] They are BG, Chevron, Shell, Statoil, Centrica, Gazprom, Union Fenosa, Thailand's PTT, E.ON Ruhrgas, India's Gail, Kogas and local independents – Oando Group and Sahara Energy
[409] EIA, Country Analysis Briefs – Algeria, at http://www.eia.doe.gov/emeu/cabs/Algeria/NaturalGas.html



Meanwhile, Nigeria is the major stakeholder in the West African Gas Pipeline project and appears to be making progress on the proposed Trans-Sahara Gas Pipeline (TSGP)[410]. The EU has offered both financial resources (Loan Provision) and political support for the project, while Gazprom of Russia has signed an MOU on gas exploitation and transportation with NNPC. In addition, Totalfina Elf has indicated interest to participate in the project with other investors.

A baffling issue about the TSGP is that Nigeria lacks a domestic gas grid and is considering an investment to export its gas into Algeria's grid. Besides, as a key member of the Gulf of Guinea Commission[411] Nigeria aims to access Equatorial Guinea's gas deposits in exchange for gas supply to that countries' LNG project.[412] Although Nigeria's reserve could last for over 100 years,[413] whether there would be sufficient gas supply for the above projects is another issue.

It appears that the current administration – led by Umaru Musa Yar' Adua - is determined to enforce the Gas Master Plan (especially to enhance electricity generation). The question that continues to bother industry stakeholders and prospective investors is whether domestic gas prices would be attractive to both

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[410] The proposed 4,500km pipeline would run from Warri (Southern Nigeria) through Niger Republic and the Sahara desert to Hassi R'Mel in Algeria.
[411] Blackwell Publishing, *Gulf of Guinea*, African Research Bulletin, 2006
[412] Nigeria's Energy Minister (Edmund Daukoru) quoted in The Guardian, *Nigeria earns N187 billion from gas in eight years*, at http://www.nigerians-abroad.com/news/economy/nigeria-earns-n187bn-from-gas-in-eight-years/ (23/02/07).
[413] BP Statistical Review of World Energy, June 2007.

demand and supply. Perhaps, it is too early to speculate on Nigeria's domestic gas pricing regime given its history of policy inconsistency and unstable polity.

2.3.6 Trinidad and Tobago

Trinidad's economy which was initially dominated by oil has now become a gas-based export region.[414] Over fifty percent of Trinidad's exploitable gas deposit is now dedicated to LNG export - which has replaced oil as the prime source of government revenue. Trinidad became an exporter of LNG with the coming on-stream of the 3mtpa Atlantic LNG plant in 1999. Today, its Atlantic Group[415] has become the largest US LNG exporter with four trains and total liquefaction capacity of 15mtpa. It provided over six percent of Europe's LNG imports to Italy, Spain and the United Kingdom in 2006[416]and given its contract obligation (Table 2.14), could remain a relevant exporter in the Atlantic Basin (US and Spain especially).

Table 2.14 Trinidad's LNG Contract Obligation

Exporter	Importer	Country	Volume (mtpa)	Volume (Bcm)	Start	End
Atlantic LNG	Tractebel LNG	USA	1.75	2.40	2000	2020
Atlantic LNG	Tractebel LNG	USA	0.22	0.30	2003	2023
Atlantic LNG	BG	USA	1.50	2.06	2006	2026
Atlantic LNG	BG	USA	1.61	2.20	2003	2023
Atlantic LNG	BG	USA	0.80	1.10	2003	2023
Atlantic LNG	Gas Natural	Spain/USA	0.73	1.00	2003	2023
Atlantic LNG	Repsol	Spain/USA	0.66	0.90	2003	2023
Atlantic LNG	Repsol	Spain	1.68	2.30	2001	2021
Atlantic LNG	Gas de Euskadi	Spain/USA	0.73	1.00	2003	2023
T.T's Total			**9.68**	**13.26**		

Source: Gas Strategies

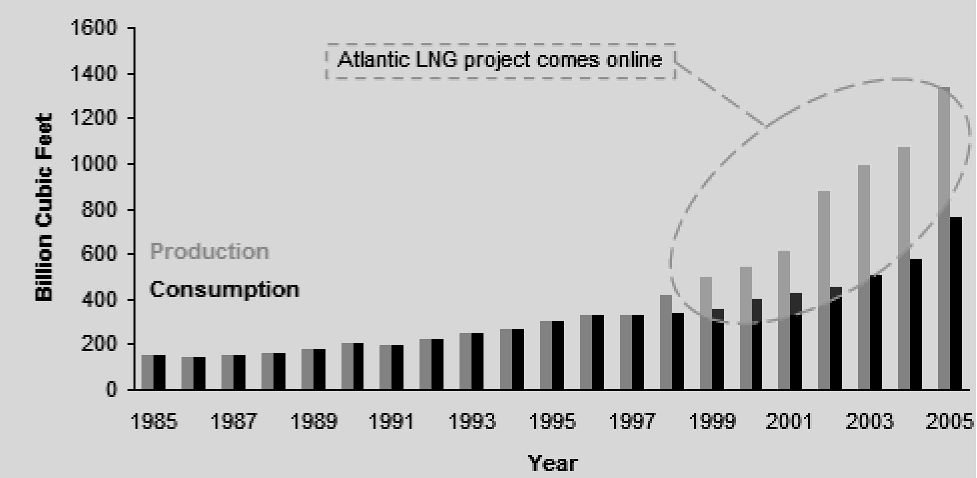
Meanwhile, Trinidad and Tobago operates a *single buyer model* in its domestic gas market. The National Gas Company (NGC) is the sole buyer,[417] transporter and seller of a natural gas to downstream users in the economy. Gas price indexation is applied in the petrochemical industry but regulated tariffs apply to domestic users.

[414] In addition to natural gas, Trinidad also exports steel, ammonia, LNG, and methanol.
[415] Three companies operated by Atlantic LNG but owned by National Gas Company of Trinidad and Tobago jointly with the subsidiaries of Suez LNG, BG and BP.
[416] US EIA at http://www.eia.doe.gov/emeu/international/LNGimp2006.html
[417] It buys gas from the main producers - EOG, BG and BP.

Although price indexation is efficient,[418] the tariff system for non-industrial users is non-competitive.

Consequently, (as Figure 2.19 indicates) domestic gas consumption has increased rapidly with economic growth and could hamper future exports. In 2006, more than half of Trinidad's gas production was consumed domestically - over ninety percent of its primary energy demand.[419] Due to the uncertainty of future revenues from gas reserves, Trinidad created a stabilization fund[420] before the reserves run out in twelve years[421].

Figure 2.19 Trinidad's Gas Production and Consumption



Source: EIA International Energy Annual

However, experience has shown that such funds are no cure-all,[422] and so government imposed a moratorium on new LNG projects. Given that its proven gas reserve is about 0.3% of the global total,[423] there are plans to initiate a bidding round for offshore gas acreage this year (2009).

Table 2.15 LNG Exports to Atlantic Basin Markets[424] by Atlantic Exporters[425]

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[418] Within a domestic context, this process ensures profit-splitting between NGC and petrochemical companies as the price of petrochemical products increase.
[419] B.P., *Statistical Review of World Energy, 2008.*
[420] Wagbara, O., *Why does Trinidad and Tobago need a different Fiscal Regime for Gas?* I.E.L.T.R, December 2005.
[421] B.P., *Statistical Review of World Energy, 2008.*
[422] Baunsgaard, T; *A primer on mineral taxation,* IMF Working Paper WP/01/139
[423] Stern, J., *Gas as a Transitional Fuel*, Table 1, OEF, February 2008.
[424] This includes exports to other Atlantic Basin Countries apart from France; Italy; Spain; United Kingdom and the USA were considered.

Exporters	1995[426] Bn m^3	% of LNG Export	2000[427] Bn m^3	% of LNG Export	2005 Bn m^3	% of LNG Export	2008[428] Bn m^3	% of LNG Exports[429]
Algeria	17.38	97.16	26.93	100	25.60	99.7	19.38	88.63
Egypt	-	-	-	-	6.63	95.7	9.13	64.94
Libya	1.28	100	0.78	100	0.87	100	0.53	100.00
Nigeria	-	-	4.57	100	12.04	100	16.01	77.95
Qatar	-	-	2.11	14.43	4.64	17.1	8.07	20.34
Trinidad	-	-	3.64	91.24	14.01	100	15.39	88.66

Source: US EIA

In summary, given the above discourse and Table 2.15, one can reasonably expect that the six exporting countries would become more relevant in the various gas markets within the Atlantic Basin. It is important, before concluding this chapter, for one to highlight the role of some Atlantic Basin gas producers excluded from this work.

2.3.7 Excluded Gas Exporters

Venezuela does not have LNG capacity but has a small amount of gas reserves.[430] Angola and Equatorial Guinea are new entrants to LNG trade and their gas reserve is very small. Consequently, there seems a thin basis for any sort of commentary on the above countries. Iran lacks liquefaction capacity but is a very important natural gas exporter and reserve holder. Since Iranian export is yet to affect gas supply in the Atlantic Basin, it is not included in this work. But why exclude Russia?

Russia

Gas has been flowing from Russia to Europe for the past four decades. Their energy trade relations have been very distinguished from the Soviet Union, through its collapse and to date. During the Soviet era, trade relations were between the

[425] Only exports from the following countries were considered: Algeria, Egypt, Libya, Nigeria, Trinidad and Qatar.
[426] Energy Information Administration, World LNG Imports by Origin, 1995
[427] Energy Information Administration, World LNG Imports by Origin, 2000
[428] BP, Statistical Review of World Energy, 2009.
[429] That is, as a percentage of each country's total LNG export.
[430] Venezuela's proven gas reserve was about 2.7% of the global total as at January 1, 2008, according to EIA, *International Energy Outlook 2008*.

Western European countries and the Central/Eastern European countries that were members of the Council for Mutual Economic Assistance (CMEA)[431].

Much recently, with the advent of the European Union (EU), a new relationship has been formed between Russia and Europe. Russian gas export to Europe, which reached a record 154.30Bcm in 2005, has been hampered by lingering price disputes with Ukraine.[432] On the one hand, the EU wants Russia to ratify the 1994 Energy Charter Treaty and Transit Protocol, as well as, access to Russia's upstream gas sector. On the other hand, Russia is seeking access to Europe's retail gas markets.

So far, cargoes from Sakhalin II LNG[433] were delivered to Japan and China in April 2009. Meanwhile, Gazprom has signed an LNG swap agreement with Sonatrach of Algeria to deliver Algerian LNG to the US. But doubts exist about Russia's capacity[434] to meet its future gas supply obligations due to rising domestic consumption – 55% of the primary energy demand.[435] The high domestic gas demand has been attributed to inefficient pricing but on-going reforms could improve Russia's domestic gas price regime.[436] While Russia could certainly play a role in the Atlantic Basin, it is doubtful that this can be significant prior to 2015. So, given the timescale, scope and criteria applied in here, Russia is excluded from the study.

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[431] Stern, J., Soviet and Russian Gas: The origins and evolution of Gazprom's export strategy, (Oxford: Oxford Institute for Energy Studies, 1999).

[432] Gazprom cut gas supply to Ukraine completely from 1st to 4th January, 2006; by a quarter on 3rd March 2008; and also from 1st to 19th January 2009. For a detailed history of the dispute and impact on Europe, see Stern, J., *The Russian-Ukrainian gas crisis of January 2006*, at http://www.oxfordenergy.org/pdfs/comment_0106.pdf January 16 2006; Pirani, S. (Ed.), Russian and CIS Gas Markets and their impact on Europe, 2009 and Pirani, S. et'al, *The Russo-Ukrainian gas dispute of January 2009: a comprehensive assessment*, February, 2009 at http://www.oxfordenergy.org/pdfs/NG27.pdf

[433] The 9.6mtpa liquefaction plant, located in Prigorodnoye, was launched in February 2009, and it is the first Russian LNG plant. Sixty-five percent of its liquefaction capacity has been contracted to eight Japanese firms and the rest would be exported to Korea and United States through Mexico.

[434] Russia's gas production could last for over forty-seven years, at the 2006 rate. Its proven gas reserve was 27.2% of the global total as at January 1, 2008, according to EIA, *International Energy Outlook 2008*.

[435] At the end of 2006: *BP Statistical Review of World Energy 2007.*

[436] Stern, J., *Gas as a Transitional Fuel*, Table 1, OEF, February 2008.

2.4 Conclusion

Effort has been made here to show the role of LNG in global gas trade and how this has evolved over the past two decades, particularly in the Atlantic Basin. The above description of potential demand;[437] infrastructure; legal and regulatory regimes for LNG indicate the willingness of governments to secure future energy supply through LNG.[438] While market and regulatory reforms is attracting more import infrastructure, it may require something more to attract sufficient LNG cargoes – higher prices[439] or change in pricing regime. Besides until emerging climate change policy objectives are realised, all forms of gas would be needed globally.

A relevant issue, therefore, is the extent to which Middle East and African gas producers could be relied upon for guaranteed supply. How certain can one expect simultaneous gas supplies from MENA to the Atlantic Basin, Asia Pacific and neighbouring MENA countries. In this regard, an attempt has also been made to highlight the complex internal and geopolitical exigencies that could arise. Although, LNG import is becoming widespread, it is also important to note the potential risks inherent in underutilized terminals. Because most of them – especially in East Coast United States - operate below installed capacity, there are serious economic and regulatory implications.

This, however, does not demean the fact that terminal owners could engage in and benefit from arbitrage. Rather, they offer exporters negotiating leverage[440] or incentive to defend falling prices by colluding. Perhaps, it will not be very difficult to imagine that UP or VC will be workable in these markets if:

- no other significant incremental pipeline supplies will be available to these markets and/or
- LNG becomes a much more important part of total gas demand, probably at least 20-25%

[437] Despite the short term surplus created by the 2009 global economic crises.
[438] Mainly to increase LNG imports, in addition to new pipelines and renewal energy projects.
[439] Ceteris paribus – but, if a significant fall in demand occurs in many importing regions this may not be the case.
[440] That is when the demand for natural gas or LNG is high in some major importing markets.

Conclusively, the above discourse shows the potential influence that LNG exporters could assert on gas trade. Sometimes, the entry of large scale LNG into the UK and US markets affects[441] the NBP and HH respectively.[442] However, it is notable that most Atlantic Basin importers (apart from Spain) are mainly pipeline gas markets. And because LNG contributes only a small percentage of total gas supplies, pipeline gas sets the price.

So, unless the situation changes significantly – in the foreseeable future – an exogenous effort[443] may be required for the potential power to materialize. Meanwhile, this chapter has revealed countries that are essential for an LNG export organization to wield such price influence or market power. In addition, it has rationalized the choice of importing and exporting countries within Atlantic Basin - chosen for the purpose of manageability and detailed analyses. To fully set the background of this work, the next Chapter considers the principles that underlie pricing in international gas trade.

[441] Though partially. So far, no research has been undertaken to determine the extent to which LNG imports affects the HH and NBP prices.
[442] Fesharaki, F., *Asian, global LNG markets in transition are defining future*, in Vol. 4, Issue 3, Oil and Gas Journal, July 01, 2007.
[443] Perhaps, a collective action by LNG exporters to influence LNG prices or the principles of price determination

CHAPTER THREE

PRICING IN INTERNATIONAL GAS TRADE

3.0 Background

Price has remained a central issue since the emergence of gas as an important energy source. Whether gas is for domestic or international trade, the primary issues of price, politics and profitability are intrinsically intertwined.[444] Like Chapter Two, this chapter contributes in setting the scene of the book as it describes pricing in international gas trade[445]. Divided into 3 parts, section 3.1 captures the underlying theoretical basis of price determination. Section 3.2 briefly traces the evolution of cross border gas pricing concepts and details the different pricing regimes for international gas trade. Relying on the theoretical foundations of sections 3.1.and 3.2, a uniform pricing concept for Atlantic Basin LNG trade is proposed (in section 3.3).

3.1 Theoretical Framework

Price may be defined as the instrument or mechanism for achieving efficiency (allocative and/or productive) as market signals are transmitted in the course of trade[446]. In different markets[447], price mechanism functions differently as players interact. Because most energy yielding resources are non-renewable, strategic and political in nature[448], they are priced in a distinct manner. Also, they have other characteristics, peculiar to their use and industry, which fundamentally determine how they are priced. For petroleum (both oil and gas):

- Production, generally, involves a producer[449] and the resource owner[450] (private or state)
- Investments are very large and may also be risky (due to asset specificity along the value chain)

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[444] Victor, D.G; et'al, Natural Gas and Geopolitics: from 1970 to 2040, P.8, (2006)

[445] That is, trans-border upstream/wholesale gas price. Downstream (domestic) gas prices are not discussed but mentioned only where necessary. **Gas refers to both Pipeline and Liquefied Natural Gas (unless when explicitly distinguished). Natural Gas simply means Pipeline gas.**

[446] Exchange of goods and services in an economy (domestic or global)

[447] Markets are variously classified as perfectly competitive; monopolistic; duopolistic or oligopolistic.

[448] Market imperfections occur due to externalities and lack of information arising from these characteristics.

[449] This could be an IOC, NOC, Joint Venture or an Agent of the Resource Owner.

[450] Negotiating and collaborating to make investment and production decisions.

- Demand is mostly inelastic and continually interacts with concentrated supply[451]

Given their effects on price, all the above deserve extensive consideration. However, for the purpose of this research, the exhaustible, physical and investment characteristics are emphasized - they are more relevant to the theory and principles gas pricing discussed in the next section.

3.1.1 Basic Theories of Price Determination

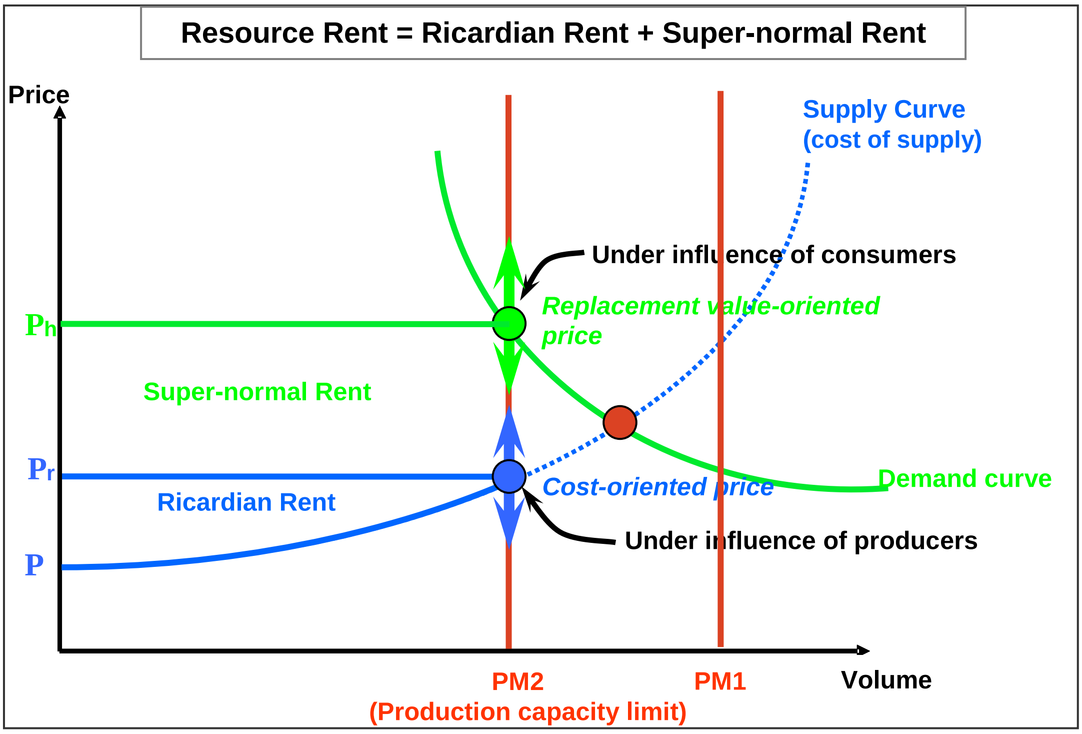
Dasgupta[452] defined natural resource price in terms of *ground rent*[453] and *cost*[454] while assuming a competitive market, as: $q_t = p_n (1+r)^{t-n} + c_t$ *Where*: q_t is price in time t; $p_n (1+r)^{t-n}$ is the ground rent (p_n) compounded at interest rate 'r' over the period (t-n)[455] and c_t is the cost in time t. According to Dasgupta, the ground rent on a resource is inversely related to the amount of deposits[456] available, while cost is a function of available technology[457]. His hypothesis regards available deposits as the key measure of resource abundance/scarcity, but this is not always the case. It can, therefore, be described as narrow and insufficient for determining natural resource price in international trade.[458]

However, the theoretical background for understanding non-renewable natural resource pricing hinges on the concepts of rent[459]. One of such is the Ricardian rent concept, named after David Ricardo. It relates to production cost differentials[460] which indirectly benefit producers. Such differential rent, due to site quality and location, relative to market, is called Ricardian rent[461] (indicated as the area **P_rOP** in

[451] Petroleum reserves are mainly concentrated in a few countries around the globe.
[452] Dasgupta, P., *Natural Resources in an age of substitutability* in Kneese, A., and Sweeney, J., (Ed) Handbook of Natural Resource and Energy Economics, Vol. III, 1993.
[453] Ground rent or royalty is the appreciative value of a natural resource deposit underground.
[454] This includes the various costs along the supply chain.
[455] In other words, it is the rate at which a natural resource deposit appreciates underground over time from period 'n' to period 't'.
[456] That is large deposit (resource abundance) equals small ground rent and vice versa, while holding demand (present and future) and available substitutes constant.
[457] Technology is dependent on innovation from Research and Development.
[458] One is appreciative of the fact that a few pertinent issues have been highlighted.
[459] It is also called Economic Rent; Resource Rent; Ground Rent or Producer Rent.
[460] Costs vary across production fields, based on nature of the resource, size, geology and location relative to the market, within a country and across national boundaries.
[461] This term is derived from David Ricardo's work on Labour, Land and Rent. Ricardo, D., Principles of Political Economy and Taxation, 2001.

Figure 3.1). Through technological developments, production and transportation costs fall and consequently, differential rents as producers compete for market share. In respect of price determination, the resource owner (producer) may choose to earn part or all of the rent. The Ricardian rent underlies the *cost-plus*[462] price mechanism applied in gas trade.

Figure 3.1: Non-renewable Petroleum Resource Pricing[463]



The second concept of pricing, linked to the nature of petroleum markets, is called super-normal rent or profit.[464] Supply in petroleum markets consistently lags demand.[465] The gap PM2-PM1 in Figure 3.1 could be demand-driven or due to inadequate investments or the existence of market power – this explains why producers obtain super-normal profits.[466] So, super-normal or scarcity rent is

[462] This pricing principle is described fully in section 3.1.2 below.
[463] Extracted and modified from Energy Charter Secretariat, *Putting a price on Energy*, March 2007.
[464] Stevens, P., *Introduction to the economics of energy*, in Stevens, P. (Ed.) Energy Economics, Vol. 1, 2000.
[465] That is the gap **PM2-PM1** in Figure 3.1. This gap could also arise from the long lead time of petroleum projects.
[466] When market power is exercised, in the form of constrained supply, monopoly rent is created – captured in the rectangle P_rP_h in Figure 3.1. This rent could also be due to indivisibility of capital - but this leads to a cyclic process of high-low prices

generated as the market *competes* for constrained supply[467] or pays prices above the resource owner's marginal cost (shown as the area **P_hOOP_r** in Figure 3.1 above).

Arguably, the existence of super-normal profit set the conceptual framework for pricing energy resources based on replacement value - *netback pricing*.[468] While the logic of scarcity-induced rent seems clear, the need to consider the opportunity cost of currently produced reserves is often ignored. The price of an exhaustible resource can have a number of components. These include:
Marginal Cost + resource rent[469] + correction for external costs[470] + rent (due to monopoly or other market distortions). Normally, a private supplier will not consider the social costs and so exclude external costs. But all of these will show up in the surplus – so, suggesting that the scarcity rent captures the super normal profit is misleading.

Some proponents of Hotelling have also termed this concept of super-normal profit "Hotelling rent"[471] Attempting to resolve Hotelling's work, Sweeney reiterates that it is logical, but "its rigid cost assumptions make the case less useful than more general cases for explaining or predicting depletable resource markets"[472]. In this author's opinion, the existence of supernormal profit does not follow from Hotelling's postulations. Moreover, his work is based on the finiteness of petroleum resources - part of a debate that would continue for some time.[473]

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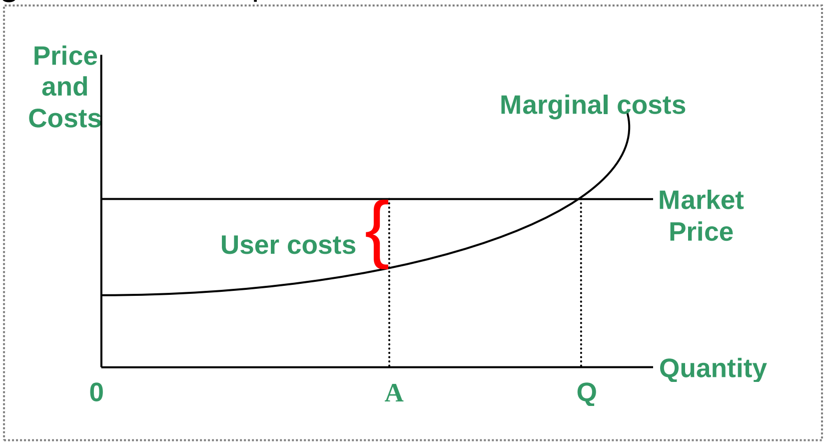
[467] The super-normal profit that results from constrained supply or market power is a temporary phenomenon but this action is perceived by market participants as persistent.
[468] This method of price determination is extensively described in section 3.1.2 below.
[469] As argued in Hotelling's Theorem.
[470] That is externalities - due to environmental, security and other considerations.
[471] Harold Hotelling had argued that resource-rich nations aim to optimize the benefits accruable from their resources by discounting future revenues based on interest rates that reflect government's expectation. His theorem posits that the interest rate determines the annual revenue as an exhaustible resource is exploited and the resultant price path makes a backstop technology an economic substitute. For more on this, see Hotelling, H., *The Economics of Exhaustible resources*, Vol. 39, No. 2, The Journal of political Economy, 1931; and Minnitt, R., *Frontiers of usefulness: the economics of exhaustible* resources, Vol. 107, The Journal of Southern African Institute of Mining and Metallurgy, August 2007.
[472] Sweeney, J., *Economic theory of depletable resources: An introduction*, in Kneese, A., and Sweeney, J., (Ed) Handbook of Natural Resource and Energy Economics, Vol. III, 1993.
[473] Petroleum (Resource) Economists are heavily divided over what constitutes proven reserves and the peak oil discourse. Some align with geologists, who generally agree, on the finiteness of proven natural resources. While others assert that proven reserves are dynamic and would continue to change due to technological innovation, cost and price.

Meanwhile, Tilton disputes the notion of Hotelling or scarcity rent but rather refers to it as user costs because they are not true economic rents. According to him, User Costs "are the present value of the lost future profits associated with a unit increase in current production".[474] So, they arise (as Figure 3.2 shows) from producing quantity '**0A**' rather than '**0Q**'. Furthermore, one can deduce from Figure 3.2 that User Costs do not appear to be a super-normal profit if market price is competitively determined.

Figure 3.2 Market price and Resource Owner's User Costs[475]



Taken together, the Ricardian rent and user cost (super-normal rent) make up the *economic rent* or *resource rent* or *depletion premium* of a natural resource. This rent has been the basis for gas price determination in both domestic and international trade.[476] In real life, as a natural resource is commoditized, the determinants of resource rent vary as demand interacts with supply.

So, there is no agreement, amongst economists, on how the rent is generated – either driven by demand or due to constrained supply. Rather, stakeholders' perspective affects how this rent[477] is defined and earned through pricing principles. Then, what principles underlie pricing in international gas trade?

[474] Tilton, J., On borrowed time? Assessing the threat of mineral depletion, 2003.
[475] Tilton, J., On borrowed time? Assessing the threat of mineral depletion, 2003
[476] This is not to imply that commercial participants started with Ricardo or Super-normal rent and decided how to price gas. Rather, it is the nature and evolution of the markets; geological investment and profits that have defined gas pricing.
[477] Or the component parts of the rent.

3.1.2 Pricing Principles[478] in International Gas Trade

Against the above theoretical background some principles of pricing in international gas trade have evolved – Cost-plus[479] and replacement value (applied in the Groningen and Netback mechanisms). This sub-section rigorously documents their development up to the three current regimes - Hub based spot pricing (NBP and Henry Hub); oil product indexed netback market pricing (common in Continental Europe); and crude oil linked pricing (common in the Pacific Basin[480]). Other views and perspectives on these principles, in the literature, are also captured.

3.1.2.1 Cost-plus

This principle determines gas prices by adding a margin[481] on the cost of production[482]. Cost-plus mechanism was commonly used for pricing domestically produced gas sold to domestic utilities before the EU Gas Directive in 1998. Pricing in domestic gas markets is, however, not addressed in this book due to its intricate nature. When adopted in regional gas trade, it is referred to as *subsidized export pricing*. In such instances, gas is exported based on domestic price(s) within the exporting country.

The theoretical interpretation, in this case, is that the exporter indirectly shares the super-normal rent with the importer. This is typical of economically integrating/integrated regions like in West Africa's Gas Pipeline project[483]. Why would a producer adopt such a pricing regime for export? As long as the producer recovers its costs and some return on its investment, it is willing to sell gas that may not have any other use elsewhere. So, when the producer wants to develop a gas market or is interested in penetrating a market, this can be the pricing policy.

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478 These are basic economic principles or arguments that underlie price determination in gas sales contracts.
479 Cost plus pricing, was used predominantly in regulated national gas markets but more recent application of its principles is discussed in section 3.1.2.1.
480 A detailed history of LNG pricing in the Asia-Pacific region is avoided here because it would be a huge task and the book is about the Atlantic Basin. But as LNG trade and pricing evolves, the Pacific has become the driving force and cannot be ignored. Its pivotal role in the determination of LNG prices currently is fully taken into consideration in Chapter Six.
481 Producer premium (Ricardian rent) based on a fixed percentage or average cost of production.
482 At the well head or further down the LNG supply chain (that is after regasification – see Table 3.1 below).
483 Some participating countries (Togo and Benin Republic) decided to forego their right to charge transit fees. It is important to note, however, that this is a very rare phenomenon.

This principle was commonly used in integrated LNG projects because Capital Expenditures (CAPEX) along the value chain is very high. For clarity, an illustration with Table 3.1 indicates the usefulness of this principle for pricing purposes.

Table 3.1 Cost-Plus pricing in an integrated LNG Project[484]

	CAPEX[485]	**Cost-Plus**
Development Gas Field[486]	$2.6Bn	$1.60[487]
Liquefaction	$3.2Bn	$2.44
Tankers[488]	$3.2Bn	$1.96
Regasification	$1.0Bn	$0.78
Total	**$10Bn**	**$6.78**[489]

The above process of price determination is, however, no longer common but the underlying principle is sometimes applied within the unbundled LNG chain. Now, the principles of cost-plus pricing are adopted in negotiating the fixed component in LNG pricing formula or for setting minimum export price. For instance, in a simple linear LNG price function, the fixed element should be sufficient to cover the cost of feed-gas, as well as, fulfill debt service obligations – which are operational costs.[490] This leads us to the second principle of pricing in international gas trade – replacement value.

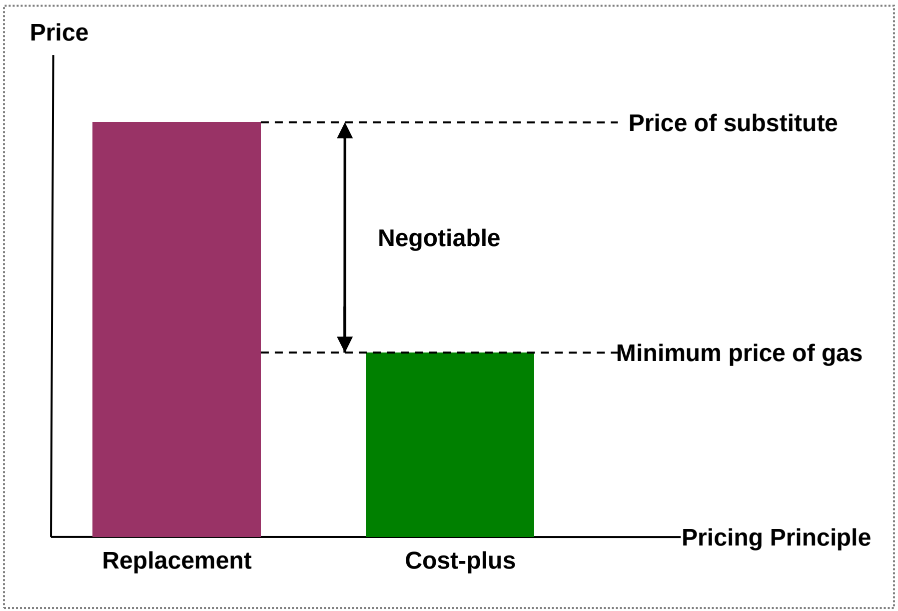
3.1.2.2 Replacement value

Replacement value mechanism assumes that the price of a substitute is a measure of a commodity's value. The price of gas, at a consumption point[491], is therefore, equal to the price of an alternative fuel at the same point. This approach assumes

[484] Modified extract from Jensen, J., The Development of a Global LNG Market – Is it likely? If so when? 2004
[485] Capital Expenditure (of $10Bn) is allocated as follows: 58% on development of gas field and Liquefaction infrastructure; 32% on ten LNG Vessels (at $320Mn each) and 10% on Regasification plants.
[486] Greenfield development of around 280billion M^3 of gas reserves to serve as feedstock for a twenty-year LNG export contract.
[487] 2007 data reveals that, for a cross-section of LNG exporting countries, domestic gas prices ranged from $0.75 to $2.60 /mmBtu. For those with fairly robust gas industries, $1.60/mmBtu was the standard feedstock cost in that year.
[488] Assume that the vessels would cover a distance of 2,400 Nautical Miles.
[489] This is a description of price on the basis of costs and a reasonable profit on investment - sometimes referred to as Cost-of-Service.
[490] A detailed description of LNG pricing is presented in section 3.2 below.

that consumers should pay an amount equivalent to the price of alternative fuels. While the price of substitutes may not be an efficient measure, the main purpose of using this method was to ensure penetration of gas in consuming markets. Perhaps, with the globalisation of gas trade, this issue of efficiency has become very pertinent and needs to be addressed. Like the cost-plus, the replacement value principle is applied in both domestic and international gas trade. It underlies the *netback pricing method* in cross-border gas trade in Europe.[492]

Figure 3.3 Cost plus versus replacement value[493]



But, neither cost-plus nor replacement value approach significantly considers the exhaustible nature (User costs) of the energy resource. Rather, as Figure 3.3 illustrates, "*the difference between the netback value and the cost plus value constitutes a rent that is shared among exporters and importers*".[494] And, this negotiable rent is strategically split[495] based on bargaining power - derivable mainly from the prevailing market situation.

For natural gas, the case is more complex because it lacks a captive market[496] - but is becoming a global commodity. Gas has to compete with alternative fuels for all its

[491] Depending on its use, but usually at the burner tip, in a particular sector, location or importing country.
[492] The netback method is rarely (or indirectly) used for pricing gas in the domestic market.
[493] Dorigoni, S. and Portatadino, S., *LNG development across Europe: Infrastructure and regulatory analysis*, in Vol. 36, Energy Policy, 2008.
[494] Jensen, J., The Development of a Global LNG Market – Is it likely? If so when? 2004.
[495] The mechanism for sharing the rent varies and depends on the parties involved; terms of trade; mode of transportation; trade relations and other non-economic factors.
[496] Captive market in the sense that crude oil products are the predominant transportation fuels.

end-uses and it cannot risk being overpriced. This fundamental issue – substitutability – has made the pricing of natural gas persistently ambiguous. So, there are at least two perspectives to the allocation of consumer and producer surpluses through the price mechanism. Given substitutability, gas importers argue, the price of gas has to be sufficiently low as to make it relatively competitive[497] in each usage. Therefore, they adopt several approaches to bring down the replacement value (price of substitute fuels) - through regulatory policies, environmental policies, as well as, domestic pricing policies.[498]

But, the price has to be, simultaneously, high enough to attract investments, as well as, provide investors/producers with some profit. Hence, exporters (gas producers) endeavour to push up the minimum price (in Figure 3.1) or the opportunity cost of gas through alternative gas utilization projects.[499] Their ability to do this has been constrained by unbundling of the LNG chain. The latter condition has given rise to what may be termed exporters' dilemma. Consequently, exporters have argued for the pricing of natural resources on the basis of energy content.

While, the importers' argument seems logical, it is inconclusive and deficient in cross border trade, because energy fuels vary - in terms of source, nature (exhaustible/renewable), strategic importance (geopolitical or commercial). While each perspective could ensure the setting of a theoretical price floor or cap (as depicted in Figure 3.1), it is notable that none clearly identifies how resultant rents would be shared. Rather, the perspectives underscore price regimes used in international gas trade at different periods. Some of these regimes are discussed below.

Netback mechanism is an application of the replacement value principle[500]. In other words, netback pricing method deducts transportation (and any other agreed) cost from the price of an alternative fuel in the consuming market, to get the

[497] So as to remain the preferred fuel or displace substitutes.
[498] Otherwise, they impose taxes as a means of getting more rent and making gas less competitive. Some economists have argued, however, that such taxes are redistributed income rather than wealth transfer.
[499] The opportunity cost of natural gas in each exporting country significantly determines the price (or cost-plus value) of feedstock supply for any LNG project.
[500] It is sometimes considered another term for or a variant of the replacement value mechanism.

netback value, at a chosen point along the supply chain (usually upstream[501]). Depending on the agreed units - USD per mmBtu or p/therm - this may be computed as follows:

Netback market Value (Border/City Gate) = Replacement Value[502] - costs[503] - taxes[504]

Netback Value (import border/regasification terminal/wellhead =

Net back Value (Border/City Gate) - costs[505] - taxes

Alternatively, the discounted netback value could be computed by for a whole gas project:

NETBACK[506]$_{\text{ex-(ship/liquefaction/pipeline/wellhead)}}$ =

$$\frac{\sum_{t=1}^{n}\left[PV_1/(1+r)^t\right]-\sum_{t=1}^{n}\left[(C_1+O_1)/(1+r)^t\right]}{\sum_{t=1}^{n}\left[V_1/(1+r)^t\right]}$$

Where: ***'r'*** is the discount rate

P is the Price of Natural Gas (weighted average of close substitute like coal, heavy fuel oil, light fuel oil, gas oil)

V is the volume of gas delivered in years -'***t***' (from 1 to n)

C **i**s the Capital (fixed) Cost relating to element(s) of the chain in years -'***t***' (from 1 to n)

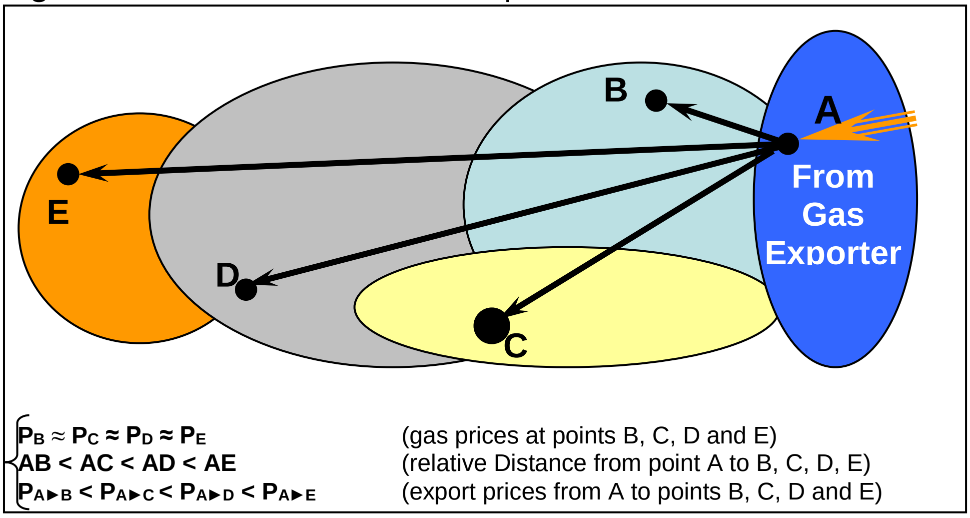
O is the Operating Cost relating to the exact/all element(s) of the chain in years -'***t***' (from 1 to n)

From the above formula, the Netback value for any gas project is highly sensitive to the price of substitute fuels; volume of gas delivered, as well as, delivery cost. Due to boil-off and other transportation losses, therefore, the Volume $V_{\text{ex-ship}} < V_{\text{ex-liquefaction}} < V_{\text{ex-pipeline}} < V_{\text{ex-wellhead}}$, in the denominator varies at every stage of calculating the netback.

[501] Depending on the mode of transportation, it could be at the liquefaction or delivery point.
[502] Rather than using one substitute, a weighted average of substitutes is used generally.
[503] To include: storage, load managing and distribution costs for bringing gas from the hub/city gate to consumers.
[504] This should include distribution, consumption and environmental taxes.
[505] To include: storage and transportation costs from the import/liquefaction terminal/wellhead to the hub/city gate.

The effect of distance on price is depicted below.

Figure 3.4 Illustration of netback price from different destinations[507]



Destination restriction clause, an integral part of the netback (replacement value) mechanism, ensured that imported gas could not be delivered elsewhere.[508] As part of gas contracts, it also enabled exporters to restrain importers from diverting or reselling gas imports (arbitrage) since different prices were offered to different markets.

Netback pricing mechanism has remained contentious, among economists, because potential buyers and sellers are always keen on the prospect of capturing substantial economic rents (mainly at each other's expense). Questioning the economic efficiency of the netback value of gas, Siddayao argues that the netback approach is a useful but economically inefficient tool for determining the value of natural gas.[509] Mashayekhi and Julius followed the discourse and argued that netback "is a poor yardstick for pricing in most cases".[510] In their opinion, one of the "factors provoking controversy is the chain of transfer points that separates the first producer from the final purchaser/consumer"[511].

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[506] Julius, D and Mashayekhi, A., The economics of natural gas: pricing, planning and policy, p.85, 1990
[507] Konoplyanik, A., *Putting a Price on Energy: International Pricing Mechanisms for Oil and Gas, with special emphasis on Russia-EU-CIS Gas Relations.* Presentation at CEPMLP Thursday Speaker Series Seminar, University of Dundee, October 2007.
[508] The application of destination and use restriction clauses has been deemed illegal under competition law.
[509] Siddayao, C.M., *Is the netback value of gas economically efficient?* OPEC Review, September 1997. Siddayao focused on domestic and regional pipeline gas markets. Besides, a great deal has happened since 1997.
[510] Julius, D and Mashayekhi, A., The economics of natural gas: pricing, planning and policy, 1990.
[511] Julius, D and Mashayekhi, A., The economics of natural gas: pricing, planning and policy, 1990.

The International Energy Agency (IEA) maintains that it works to the extent that the prices of alternative fuels (replacement values) are undistorted and competitively determined.[512] While this assertion may be true, it is highly uncertain. Besides, some gas exporters have argued, against the netback mechanism, for another pricing method termed *parity.*[513] In their view, the "*fair pricing of natural gas must be based on the parity of gas and oil fob*"[514] because they are complementary products. Based on an upstream to downstream approach, they assert that gas transportation and regasification cost should be borne by the importer.[515]

In his paper, Percebois describes both arguments[516] as inconsistent and attempts to reconcile them. According to him, the eventual contract price is a function of the prevalent bargaining power at the time of contracting and there are four possible solutions:

- *Parity at the wellhead*[517]
- *Parity of fob or prices*[518]
- *Parity of CIF prices*[519]
- *Parity at the final use…when there is excess supply*[520]

Despite the above postulation, the netback mechanism has remained relevant (dominant in Continental Europe) and there are now several methods[521] for calculating gas netbacks.

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[512] IEA, *South American Gas Prices,* Energy Prices and Taxes, 4th Quarter, 2003
[513] This pricing method has been covered sufficiently in the literature.
[514] Percebois, J. *Gas market prospects and relationship with oil prices.* Vol. 14, No.4, Energy Policy, August, 1986.
[515] Instead of being deducted from the end-user price in the replacement value mechanism.
[516]That is the Netback and Parity pricing arguments.
[517] A likely solution if there is excess gas demand in the market.
[518] This is possible if exporters have a stronger bargaining position.
[519] A possible outcome if both exporting and importing countries have almost the same bargaining position.
[520] Percebois, J. *Gas market prospects and relationship with oil prices*. Vol.14, No.4, Energy Policy, August, 1986.
[521] Some of these methods/formulas are described in section 3.2 below.

3.1.2.3 Groningen[522] price mechanism

The Dutch Groningen gas policy was one of the first applications of the pricing principles described above. The regime captures David Ricardo's notion of distance-related cost differential, as well as, the replacement value argument. Developed in 1962 by De Pous,[523] for domestic commercialization of Groningen gas fields in the Netherlands, it became a model for long term gas export contracts in Europe. The Groningen mechanism was developed initially for pipeline gas trade to enable concession holders and other investors recoup their huge capital outlay. And so contracts were designed to capture the highest price obtainable in the market[524]. It was also aimed at optimising revenue for the Dutch government.

Over the years, while maintaining its basic elements[525], the Groningen pricing mechanism has evolved in international gas trade. Most natural gas imports into Europe from the Former Soviet Union (FSU)[526] applied the Groningen mechanism. Various market-driven changes have consistently propelled the extension and application of the Groningen principles in international gas trade. It now incorporates indexation without destination/use restriction clauses (but subject to periodic review).

In North America, before deregulation, consumers pushed for and enjoyed the cost-of-service pricing – transportation/end-user concept. Also, during the same period, producers wanted 'Netback', as against "wellhead pricing"[527] to enable them retain some economic rent. Deregulation of gas markets in 1978[528] led to gas-to-gas competition and consequently netback – "basis pricing" off Henry Hub[529].

3.1.2.4 Oil product-indexed netback pricing

Oil product-indexed netback pricing, like the Groningen formula, also applies replacement value principle (netback pricing). As the name indicates, it also

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[522] Premier gas field developed for exports in the Netherlands.
[523] Then, Dutch Minister for Economic Affairs, in his Note to Parliament.
[524] This, however, depends on the chosen alternative.
[525] That is the replacement value concept and cost differentials.
[526] This includes Russian exports before, during and post Cold War Soviet era.
[527] According to the type of gas, different kinds of regulated wellhead price regimes were applied by regulators then.
[528] Jensen, T. J., *US reliance on International Liquefied Natural Gas Supply*, February 2004.
[529] Distinct from Europe's alternative fuels (rather than gas as in the UK – NBP)

incorporates the process of indexation. This mechanism, commonly applied in long term gas contracts, enables price to change[530], along with market fundamentals, without the need for random price renegotiation. "*A price indexation formula, incorporating a pass through factor, ensures that gas maintains its competitiveness in the end-use market.*"[531]

Irrespective of the *basis of indexation*[532], an indexed-netback price, fundamentally, incorporates two factors – the base price and the index price. In functional terms, it is generally stated as:

$\mathbf{P_n = P_b + P_i}$ or $\mathbf{P_n = P_b} \times \mathbf{(P_i)}$.

Where, $\mathbf{P_n}$, $\mathbf{P_b}$ and $\mathbf{P_i}$ are respectively, Netback, Base and Index Prices. However, the index element $\mathbf{P_i}$ is a *function of* the following variables: price of substitute fuel; replacement value; method and coefficient of indexation.[533]

Specifically, the base element[534] splits the price risk between producers and buyers. It essentially avails the producer/exporter sufficient revenue to service their project debts[535], while allowing the buyer to make profit after reselling or using the commodity. The index price, on the other hand, links gas to alternative fuel(s), through a defined indexation formula/coefficient. The coefficient of indexation and lag process integrates market dynamics into the contract pricing structure, while smoothening out the effects of such changes.

When crude oil derivatives form the basis for the indexation and netback value of gas, the process is termed *oil product-indexed netback pricing*. Following the acceptance of the Groningen pricing principle, in Continental Europe, it was logical

[530] Change, however, is a function of the coefficient of indexation, as well as, change in the replacement value, lag period and escalation process (discussed below).
[531] Aissaoui, A., *Lower gas prices: Have producers got the right signals?* OIES, Oxford Energy Comment, March 1999 at http://www.oxfordenergy.org/comment.php?9903
[532] That is, the price of alternative fuels or end-product used to determine the replacement/netback value.
[533] Depending on the functional relationship between gas and the alternative fuel(s) the indexation method could be direct, indirect and/or lagged. The coefficient of indexation, on the other hand, determines the degree to which changes in the price(s) of alternative fuel(s) affect gas price.
[534] Negotiated sometimes or derivable from average production cost or replacement value within the supply area.
[535] And perhaps, provide an opportunity to earn some rent.

to use domestic and industrial fuels[536] as references for determining the replacement value of gas. Because gas was indeed replacing the existing fuels – principally oil products – in those markets, oil product-based indices became the norm. Oil product-indexed netback pricing formulas[537] are, typically, of the form:

$P_n = P_0 + A \times CF_1 \times PTF_1 \times (G_n - G_0) + B \times CF_2 \times PTF_2 \times (LF_n - LF_0) +$
$C \times CF_3 \times PTF_3 \times (HF_n - HF_0)$…………………………Additive Formula

OR

$P_n = P_0 \times [A \times G_n/G_0 + B \times LF_n/LF_0 + C \times HF_n/HF_0]$….Multiplicative Formula

Where:

P_n = new price of gas

P_0 = Base price of gas

G_n and G_0 = current and old prices, respectively, of Liquefied Petroleum Gas

LF_n and LF_0 = current and old prices of Light Fuel Oil respectively

HF_n and HF_0 = current and old prices of Heavy Fuel Oil respectively

A, B and C are coefficients/pass through factors that determine the effects of the different indices (CF_1; PTF_1; CF_2; PTF_2; CF_3; PTF_3)[538] based on negotiated weights

Contracts with variants of oil-product linked pricing dominate European long term gas imports[539] by pipeline and liquefied natural gas.[540] What oil product indexation does is to ensure that gas prices remain lower (and in the same usage) relative to oil product prices. Furthermore, its smoothening effects minimize price volatility[541] (or risk) - which arguably discourages investment. This smoothening effect is possible because the oil (products) market is very liquid and not open to manipulation. However, some degree of volatility is required to generate arbitrage, attract traders and therefore liquidity to gas markets. Besides, the timing and nature

[536] Then the main fuels were oil products – Heavy Fuel Oil (HFO), Light Fuel Oil (LFO) or Gas Oil, Liquid Petroleum Gas (LPG), - and coal.
[537] Pricing formulas are either additive, multiplicative or a combination of both.
[538] The values attached to these variables depend on the agreed escalation method, frequency of price recalculation and alternative fuels. For example, a 6-0-3 time lagged price escalation implies that the gas price would be based on the 6-month average price of the alternative(s), with a zero lag and rolled over every 3 months.
[539] EC, *DG Competition Report on Energy Sector Inquiry*, SEC (2006) 1724, 10 January, 2007
[540] Examples of oil-product-based LNG pricing formulas are shown in section 3.2.
[541] Some degree of volatility, however, is required to generate arbitrage and attract investments (traders) to the market. Despite this economic fact, the timing and nature of such investments are more important given the peculiar imperfections of gas markets.

of such gas investments are more important given the peculiar imperfections of gas markets.

Despite these advantages, contract negotiations involve huge transaction costs and yet the process leaves room for price disputes or renegotiation as market fundamentals create the need to realign weights or pass through factors. The mechanism, also, does not transmit short term gas market signals[542] as they occur. Consequently, the rationale behind the continued usage of oil-product indexed pricing has been questioned (especially in Europe). While economists disagree on a better alternative to oil-product indexation, it is generally acknowledged that gas prices are influenced by oil. The question however is: how are they influenced and how strongly would they be correlated without formal contractual linkage? Similarly, it has also been argued that gas is not only used for power generation, and so power-sector-based alternative fuels should not be the basis for price determination.

The latter argument could be tenable with the globalization of gas trade. This is particularly so in a situation where destination restriction clauses are impracticable or deemed illegal. Conversely, power generators believe that alternative power generation fuels should be the basis for price determination. But at present very little power is generated from oil products and coal/power prices play only a very small role in setting the base price and the index for gas (as Figure 3.3 depicts). Some research[543] have been undertaken to further justify the argument against oil-product linked pricing.

In a major study on this issue, Stern[544] emphasized the need for a shift to gas-on-gas competition through gas hub-based pricing. Drawing from studies by Foss[545] and Wright[546], Stern posits that: *"Moving (from oil-products) to gas-indexed prices*

[542] It is worth noting, however, that the lead time for gas projects do not permit reasonable supply-side response to transient/short-term price signals.
[543] Some of such efforts are captured here but a more detailed review may be found in Stern, J. *Will gas price naturally follow oil prices in the absence of a formal index*?
[544] Stern, J., *Is there a rationale for the continuing link to oil product prices in Continental European long-term gas contracts?* at http://www.oxfordenergy.org/pdfs/NG19.pdf
[545] Foss, M., *United States Natural Gas Prices to 2015*, at http://www.oxfordenergy.org/pdfs/NG18.pdf
[546] Wright, P. Gas Prices in the UK: Markets and Insecurity of Supply. 2006.

need not necessarily exclude a mechanism to moderate volatility by adopting a price reference period of several months, just as in current long-term Continental European contracts. The difference would be that the reference period would average spot gas prices, rather than oil product prices, over a period of weeks or months."[547]

The EU's Energy Sector Inquiry Report[548], presents a neutral view. It asserts that, over the period reviewed, "on a volume-weighted basis, there is no clear commercial advantage either way" - oil or gas based indexation.[549] Focusing on the US (North America) gas market, Brown and Yucel conclude that in addition to a stable long term relationship, a complex short run link exists between oil and gas prices. In their opinion, furthermore, the continuum of market relationships, between oil and gas prices, is probably the consequence of more intricate market forces.[550]

Jensen explains that contracting through oil-linked price indexation places a volume risk on the importer[551] but in a gas-based pricing scenario, the buyer is still able to resell at the purchase price.[552] Jensen concludes that the move from oil-linked price indexation to competitive gas-based pricing shifts more of the market risk upstream to the producer/exporter.[553] This leads to the next pricing regime: Hub-based spot pricing.

3.1.2.5 Hub based spot pricing: NBP and Henry Hub

Restructuring of the US gas industry generated fundamental price changes in the North American (especially Canadian[554]) gas industry. Gas trade became more

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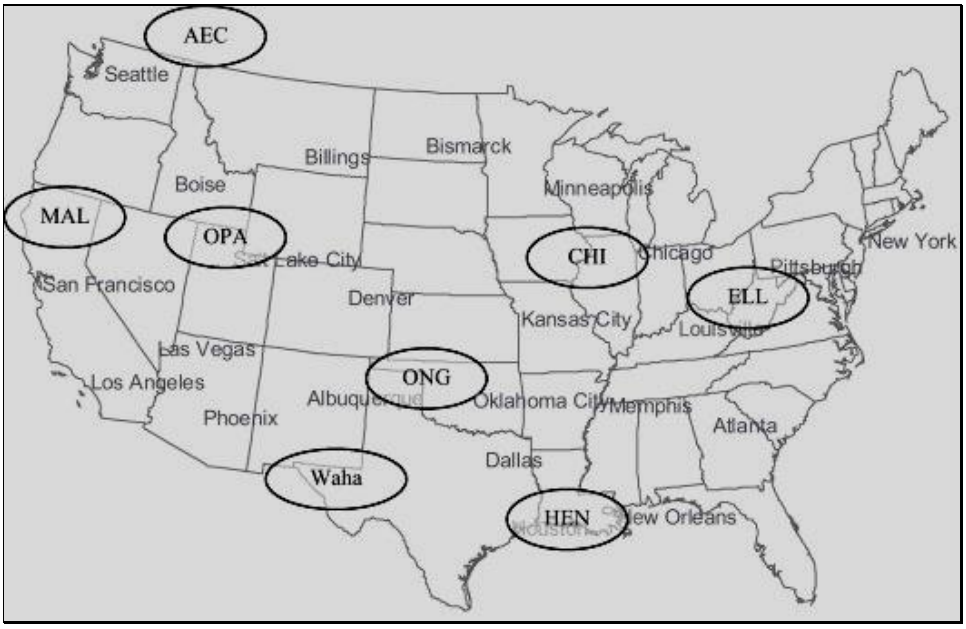
[547] Stern, J., *Will gas price naturally follow oil prices in the absence of a formal index*?
[548] Which reflects different stakeholders' views on the issue
[549] *DG Comp Energy Sector Inquiry Preliminary Report February 2006.*
[550] Brown, S.P.A. and Yucel, M.K., *What drives natural gas prices?* The Energy Journal, Vol. 29, No.2, 2008.
[551] Irrespective of the prevailing price (domestic or regional), whether it is profitable to resell or use, once contracted, the volume of gas must be taken.
[552] Provided the market is liquid enough to allow the importer to resell with an infinitesimal impact on the market price. This has not been the case in the UK, where imports have had very strong impact on UK prices from the time of interconnection with the Continent and have caused the UK to "import" oil linked prices.
[553] Jensen, J., *U.S. Reliance on International Liquefied Natural Gas Supply*, a Policy Paper prepared for the National Commission on Energy Policy, February, 2004 at http://www.jai-energy.com/pubs/natcomtx.pdf
[554] US Federal Energy Regulatory Commission (FERC) Order 380, of 1984, released local distribution companies (LDC) from their gas contract obligation and made the Canadian pricing system unsustainable. EIA, http://www.eia.doe.gov/oil_gas/natural_gas/analysis_publications/ngmajorleg/ferc380.html

transparent and involved competitive storage and transportation markets. With increased liquidity, therefore, the regional markets pooled resources from different production fields and trade developed around interconnected grids called hubs.

A hub, essentially, integrates nodes from different locations through the law of one price and subsequently transmits market signals to other regions, as gas is traded. Gas hubs now provide other services like gas processing, storage and swap. A similar process of restructuring occurred in the UK with the unbundling of British Gas and establishment of a network operator. In the case of the UK, however, virtual trading occurs across the pipeline network and the market (hub) price is determined, when equilibrium is reached, at a notional balancing point (NBP).

Figure 3.6[555] North America Natural Gas Hubs



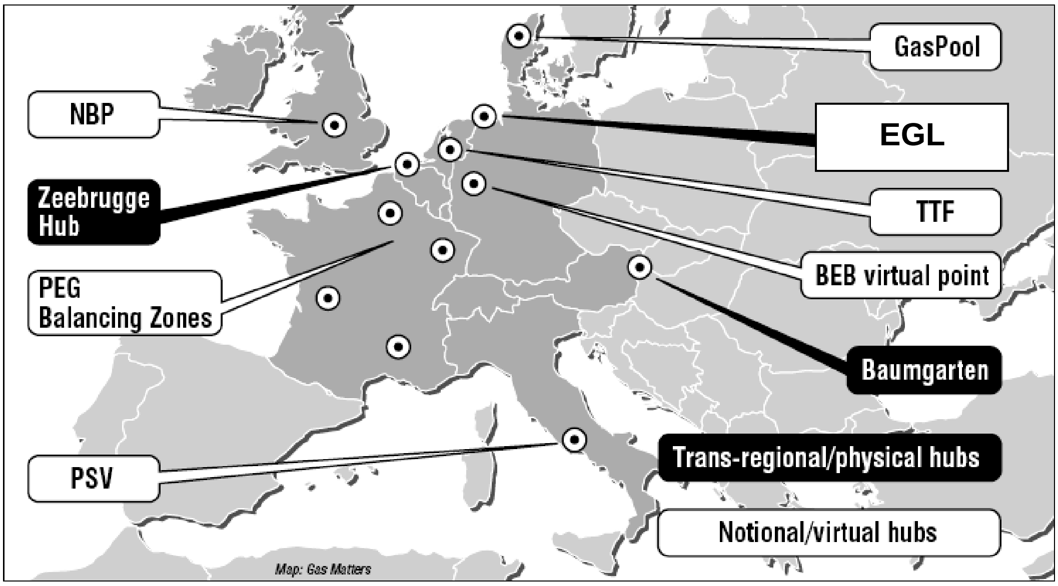
Over the years, hub-based trading has developed considerably (as Figure 3.6 shows) and the South Louisiana-based Henry Hub (HH) has emerged as the most liquid hub in the North America. Given the depth and volume of physical transactions that occur at the HH, its price is the basis[556] for spot transactions in other hubs, as well as, the *indexation*[557] of contracted gas imports in North America.

[555] Park, H. et al; *Price interactions and discovery among natural gas spot markets in North America*, Energy Policy, Vol. 36, 2008.
[556] The Henry Hub price is usually the standard.
[557] This mechanism and the application of hub-based pricing in LNG trade are discussed extensively in section 3.2 below.

The other North American hubs are: AECO (Alberta); Malin (Oregon); Opal (Wyoming); Waha (Texas); Chicago (Illinois); Ellisburg-Leidy (ELL) in Pennsylvania; HH (Louisiana); and ONG (Oklahoma).

Likewise, the UK's NBP is the most competitive hub in Europe and its price determines LNG import prices into the UK. Furthermore, it serves as benchmark for other physical and exchange-based transactions on the Inter-Continental Exchange (ICE). As a result of UK's linkage to Continental Europe[558], the NBP influences prices in other hubs as gas is shipped and/or traded between Bacton and Zeebrugge[559], across the pipeline and further on to Continental Europe. Conversely, long term oil-linked prices also influence NBP.[560]

Figure 3.7 European Gas Hubs[561]



Other hubs (shown in Figure 3.7) now exist across Europe but are yet to attain considerable level of liquidity and unable to generate competitive prices. They include: Italy's Punto di Scambio Virtuale (PSV); the Netherlands' Title Transfer Facility (TTF); Bunde-Oude at the Dutch-German border; and Points d'Echange de Gaz (PEG) located in France.

[558] The UK imports and exports gas, through the bi-directional Interconnector (IUK) pipeline that runs from Bacton to Zeebrugge in Belgium; and also from Bacton (through the BBL) to Balzgand in the Netherland.
[559] So far, Zeebrugge is the most liquid and centrally located gas hub in Continental Europe. Some researchers have argued, however, that it is indirectly an extension of NBP.
[560] The actual price movement observable, over time (annually), is a function of production, storage, demand and seasonal weather conditions in the UK and Continent Europe.

Such a process of price determination, as in North America or the UK, is known as *hub-based pricing.* Hub-based pricing is fundamentally competitive and acts as a catalyst for geographic integration and maturity of gas markets. The process involves organized spot trading on an exchange (through cash settlements or financial instruments) for natural gas deliverable next day.[562] Price, so determined, is subsequently applied in other spot and long term gas transactions (domestically, regionally or internationally). This price mechanism has developed from the competitive interaction of demand and supply, at a hub[563] or across hubs as arbitrage occurs. Arbitrage-induced market interaction is common between the UK's (NBP) and Belgium's Zeebrugge (ZB).

In the United States, through hub-based pricing, "the distinction between netback pricing and cost-of-service pricing has become blurred because of the highly competitive nature of the conventional gas supply offerings".[564] The basic distinction in Europe is between the UK – which works solely off NBP – and the rest of Europe where oil product-linked prices are dominant in long term gas contracts. For instance, future Qatari LNG supply to the UK would be based on the NBP.

There are, inherently, three important risks (price, basis and manipulation) related to natural gas trading hubs. The first risk is manipulation – actual or suspected - by the dominant player(s). This is especially serious when the hub first starts trading and is a major reason why many of the hubs in Continental Europe have few transactions. The second is basis risk which results from changes in price differentials between hubs, as well as, between gas and other fuels. 'Basis differential' is the price difference between hubs. It, essentially, reflects the transportation cost from one hub to another, as well as, the market fundamentals in one hub relative to another. The basis differential may be influenced by various market factors (ranging from changes in the volume/quality of gas supply to the level of demand in a Hub). As liquidity increases in a hub, spot prices become more

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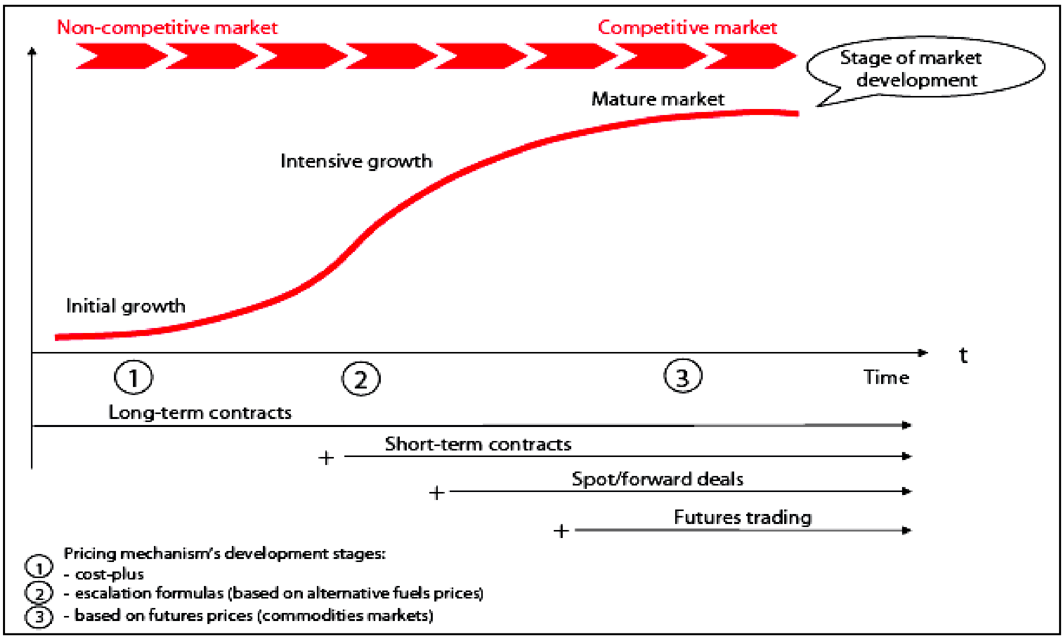
[561] Source: *Gas Matters*, May 2005.
[562] Or some time in the future.
[563] This could be a physical or virtual location.
[564] Jensen, J., *U.S. Reliance on International Liquefied Natural Gas Supply*, Policy Paper prepared for the National Commission on Energy Policy, February, 2004 at http://www.jai-energy.com/pubs/natcomtx.pdf

volatile[565] and consequently create uncertainty – price risk - in the market. According to the International Energy Agency (IEA), "*the move away from oil-linked price clauses in long-term contracts to contracts with gas-linked pricing poses a substantial challenge to gas sellers, reflecting the major changes in the marketplace*."[566]

However, because NBP and HH prices are correlated[567] to ICE and NYMEX traded futures[568] respectively, market participants are able to hedge and diversify these risks. Furthermore, exchange-based financial transactions attract investment banks; trading firms; pension funds and institutional investors to gas trade[569].

Figure 3.9 Developmental Stages of Gas Pricing Regimes[570]



Conclusively, as gas markets develop, different evolutionary price paths emerge (as Figure 3.9 indicates). It is worth emphasizing that each of the developmental stages

565 Mazighi A.E., *Some risks related to the Short-Term Trading of Natural Gas*, Page 233, Paragraph 2, OPEC Review; September 2004.
566 IEA, Security of gas supply in open markets: LNG and Power at a turning point, 2004.
567 Serletis, A. and Herbert J; *The message in North America energy prices*. Energy Economics, Volume 21, pp.471-483, 1999
568 NYMEX natural gas futures contract is the most traded globally.
569 It is important, however, to distinguish investment from speculative behaviour. The former is more desirable, most times, the latter.
570 Konoplyanik, A., *Putting a Price on Energy: International Pricing Mechanisms for Oil and Gas, with special emphasis on Russia-EU-CIS Gas Relations.* Presentation at CEPMLP Thursday Speaker Series Seminar, University of Dundee, October 2007.

has direct and indirect impact on the operational pricing regime for international gas trade. The next sub-section goes a step further to describe how these issues affect pricing and management of risks in LNG trade.

3.2 Pricing in LNG contracts

The price of LNG is a key economic variable that governs the profitability of investments and the rate of its penetration in markets. Price in a long term LNG contract reflects the energy economics and structure of the market into which the LNG is being sold.[571] So far, there have been three distinct import markets for LNG – United States; Europe (mainly Spain, France and Belgium) and Asia Pacific (mainly Japan and Korea). These markets have developed[572] in relation to pricing generally and LNG pricing specifically. Within these three markets, therefore, LNG pricing was built on different fundamental principles set out in section 3.2.3 below. The historical context sets the framework for understanding the generic principles of pricing in LNG trade within each market. First, sections 3.2.1 and 3.2.2 define LNG contract terminologies, as well as, the generic risks and economic considerations that underlie LNG projects respectively.

LNG Price, here, refers to the delivered wholesale price of LNG.[573] Pricing further down the value chain is discussed **but** only to the extent that international LNG pricing is dependent on the market – and the prices in that market – into which the LNG will eventually be sold. Price in LNG trade is also tied to the nature and funding of the LNG projects; contract and trade terms.[574]

3.2.1 Nature and funding of the LNG projects

Traditionally, LNG projects were integrated from wellhead to regasification terminal. Consequently, the concept of a minimum price floor was created to provide sufficient security for project financiers and to service the debt.[575] Project viability

[571] Roberts, P., Gas Sales and Gas Transportation Agreements: Principles and Practice (2nd Ed.), 2008.
[572] Highlighted in Chapter Two and section 3.1 above
[573] Along the LNG supply chain this would depend on the stipulated/agreed *title transfer point* and the mode of sale - FOB, CIS or DES.
[574] That is long term or spot transactions; responsibility for transportation and transfer of ownership.
[575] Miller, P., *The Chain of LNG Project Contracts*, in Greenwald, G. (Ed.) Liquefied Natural Gas: developing and financing international energy projects, 1998.

(economics); risk considerations (financing) and competitiveness of LNG in the importing market were, therefore, the key determinants of price.

The LNG contract price – compensation to the seller for taking the price risk[576] and providing the fuel – was, therefore, based on the following philosophy:

- to meet the seller's costs and expected benefit[577]
- defined in terms of alternative fuels and/or competing LNG or pipeline projects[578]
- ignores its exhaustible nature and value in terms of energy content.

The paradox of LNG pricing is that the solution should continually satisfy the above requirements, irrespective, of changing market conditions, throughout the contract period. Against this background, the contract price could result by adding the seller's costs to get a total packaged (negotiable)[579] price.[580] An alternative backward approach deducts the seller's costs from a fixed or variable demand-side replacement value to get the seller's residual rent. Consequently, depending on the prevailing supply-demand balance, buyers' ability to negotiate and enjoy lower prices is considered evidence of a buyer's market and vice versa. With the restructuring of North American and European markets, however, integrated LNG projects became history and single element projects emerged.[581]

3.2.2 Contract term and trade term

Contract term implies the duration of the Gas Sales and Purchase Agreement/Contract. It is, therefore, important that a distinction be made between long term and short term (spot) LNG pricing due to the risk implications of contract flexibility[582]. Spot trading, in LNG trade, corresponds to the logic of spatial and temporal arbitrage. It could range from one day to one year, and is a consequence

[576] On the other hand, the Take-Or-Pay clause placed the volume risk on buyers.
[577] This may be referred to as the '*seller's perspective*'. It has been argued that some LNG-exporting countries may also have strategic or non-economic agenda.
[578] Otherwise referred to as the '*buyer's perspective*'.
[579] The buyer may dispute some of the seller's underlying cost assumptions towards arriving at a mutually profitable price.
[580] Roberts, P., *LNG Pricing* Paper presented at IQPC Conference on *LNG Contracts, Trading and Pricing,* in London, March 2006.
[581] Individual liquefaction terminal, regasification terminal and shipping projects became prevalent.
[582] The regional pricing concepts described below (in section 3.2.3) apply to both long term and spot but indexation formulas are mainly different.

of cargo diversion, from their original routes, as well as, uncommitted LNG sales.[583] Spot trading and all futures market transactions are essentially subsets of 'short-term trading'.[584] Short term LNG trade is, therefore, any transaction that is not contracted on a long term basis and could occur from one day to three years. Long term LNG trade is a contracted transaction which goes from three to fifteen years.[585]

Spot transactions are convenient, flexible, and most times, involve price premium - an incentive for cargo diversion or compensation for storage/uncommitted capacity. Spot prices are fixed at the time of consummating the transactions, with no opportunity for price renegotiation or indexation. Specifically, the parties may set price at $**X** or define it as "the prevailing reference price in a chosen market"[586], at a particular point or date in the transaction[587]. An example of this process, referred to as *pricing with the market* is:

Price (P_{LNG}) = **$P_{gas/oil}$** *on the (♦) exchange as at* (date)

Where: $P_{gas/oil}$ is the price of gas or oil on the quoted exchange (♦)

Long term contract gas – pipeline and LNG - pricing, on the other hand, involves a base price and an index (for indexation). Therefore, the effects of time on price are captured through periodic price renegotiation or escalation (using adjustment factors like Consumer Price Index - Inflation). The common bases for price renegotiation are: alternative fuels and their relative market shares; switching options; and time lag.

The terms of an LNG transaction may be free on board (f.o.b) or destination ex-ship (d.e.s). An LNG sale is termed FOB when the buyer takes responsibility for

[583] Mazighi A.E; *Some risks related to the Short-Term Trading of Natural Gas,* Page 237, Footnote 1, OPEC Review; September 2004.
[584] Mazighi, A., *An examination of the international natural gas trade*. OPEC Review, Dec. 2003.
[585] Some long term LNG transactions are structured as 3-year rolling short-term contracts.
[586] This may not necessarily be the importing market but it must have a marker price for determining the spot contract price.
[587] Generally, the market price on the date (time) of loading or unloading the vessel is applied. The choice of date, however, involves a price volatility risk (or reward). Relative to the prevailing price at the time of contracting, the buyer takes the risk (or reward) if the unloading date price is applicable and actual price rise

transporting the cargo. The transaction is completed and title transferred at the export terminal, immediately the commodity is loaded into the buyer's (chartered) vessel. Destination ex-ship sale, on the other hand, is when the seller is responsible for transporting the LNG cargo to the nominated port or regasification terminal. Ownership transfer (from seller to buyer) is implied and takes effect as the LNG leaves the ship[588] at the nominated point[589] or unloading port.

Trade term[590] affects LNG price determination, risk management and rent. It, essentially, determines the transport element of the contract price and transfer of ownership. Whoever takes responsibility for transporting the LNG is compensated, through price adjustments, for boil-off losses[591] and other associated costs. More important, the trade term determines who gets the arbitrage rent[592]. While the buyer gets it in an FOB sale, the seller in an ex-ship sale. An F.O.B sale (without destination restriction clause) gives the buyer more control over the landed price and enables them to trade surplus cargoes.[593]

In order to avoid/reduce/resolve trade disputes, profit sharing mechanisms (PSMs) were designed to split the rent between exporters and importers.[594] A PSM stipulates the basis for profit sharing when a buyer (on FOB or ex-ship sale - seller's consent required) diverts a cargo to an alternative destination (higher price

(falls). Conversely, the seller takes the risk (reward), if the loading date price is applicable and actual price rises (falls).

588 Gas Matters (Drury, D.) *Destination restrictions: Algerian agreement with EC creates potential headaches for Atlantic Basin FOB* suppliers, LNG Focus, October 2007.

589 Ownership may also be transferred at a location or some point before the stipulated terminal (for tax purposes, sales to the US are delivered before entry into US territorial waters). They are, however, not termed ex-ship sale, but technically referred to as Cost, Insurance and Freight (CIF) – price covers the energy element, insurance and transportation.

590 This is another consequence of gas market restructuring.

591 Based on a fixed daily boil-off rate an allowance is calculated.

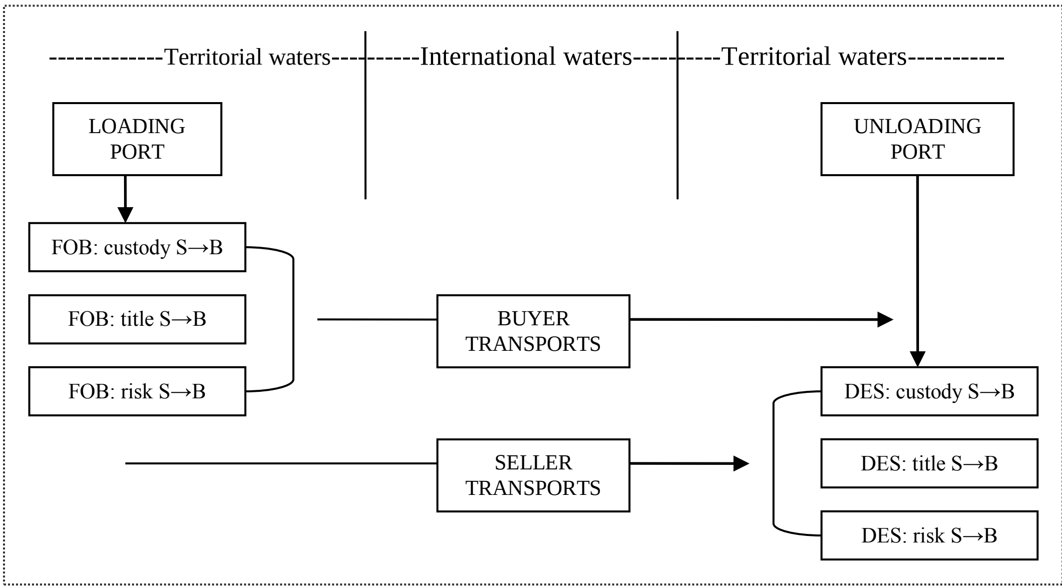
592 The abandonment of destination restriction provides arbitrage opportunities (and rent) as price signals are transmitted across regions through LNG trade. This gain from cargo diversion, referred to as arbitrage rent, has continued to be an object of negotiation or contention between LNG sellers and buyers.

593 EIA, *The Global Liquefied Natural Gas Markets: Status and Outlook*, at http://www.eia.doe.gov/oiaf/analysispaper/global/lngmarket.html (2003)

594 Drury, D., *Destination restrictions: Algerian agreement with EC creates potential headaches for Atlantic Basin FOB suppliers*, LNG Focus, October 2007.

markets). Although the mechanisms were market driven and also encouraged arbitrage,[595] they later became illegal under EU competition law.[596]

Figure 3.10 Terms of LNG Trade[597]



The EU competition law seems to be deficient to the extent that it does not acknowledge the freedom of parties to negotiate. This is because LNG transactions are not always defined as FOB, CIS or DES[598] as considered by Nyssens and Osbourne.[599] Instead, parties "*create within the LNG Sales and Purchase Agreement (SPA) a hybrid formulation for the transfer of custody, title and risk in respect of the LNG which they believe best suits their commercial circumstances"*[600]- including profit earning or sharing arrangement. As may be inferred in Figure 3.10, a continuum of trading arrangements across territorial and international waters exists for negotiating risks and rewards.

[595] Nyssens and Osborne posit, however, that in FOB contracts PSMs act as disincentive to arbitrage. But when the sale is CIF/DES, they are not "appreciably restrictive". For more on PSMs, see Nyssens, H., and Osborne, I., *Profit splitting mechanisms in a liberalized gas market: the devil lies in the detail*, Competition Policy Newsletter at http://ec.europa.eu/competition/publications/cpn/cpn2005_1.pdf
[596] The European Commission-Algeria (Sonatrach) settlement completed a prolonged legal battle by DG COMP to get rid of these clauses in all EU gas contracts – LNG and Pipeline. As part of the agreement, Sonatrach would transform all existing FOB and CIF sales contracts to D.E.S. See EUROPA, *Commission and Algeria reach agreement on territorial restrictions and alternative clauses in gas supply contracts*.
[597] Schematic was extracted from Robert, P., *Effective Title Transfer in International LNG Trades*, I.E.L.T.R., Issue 7, 2007.
[598] Sometimes parties to an LNG contract ignore these established formulations (or Incoterms).
[599] Nyssens, H., and Osborne, I., *Profit splitting mechanisms in a liberalized gas market: the devil lies in the detail*, Competition Policy Newsletter at http://ec.europa.eu/competition/publications/cpn/cpn2005_1.pdf

3.2.3 Structure of the importing market

Traceable to the regional development of gas trade, different LNG pricing concepts have also evolved to meet the structural needs of the importing markets. LNG prices are determined, generally, through netback formulas indexed to one or more of the following: price of natural gas/close substitutes in the importing market; price of natural gas/close substitutes in other importing markets; coal and electricity prices; as well as, the price of crude oil.[601] Given available energy resources, each importing market, in the Atlantic Basin, has a preferred pricing regime.[602] Beginning with a historical preview, the principles in each of the three importing markets are described below:

a) Asia Pacific

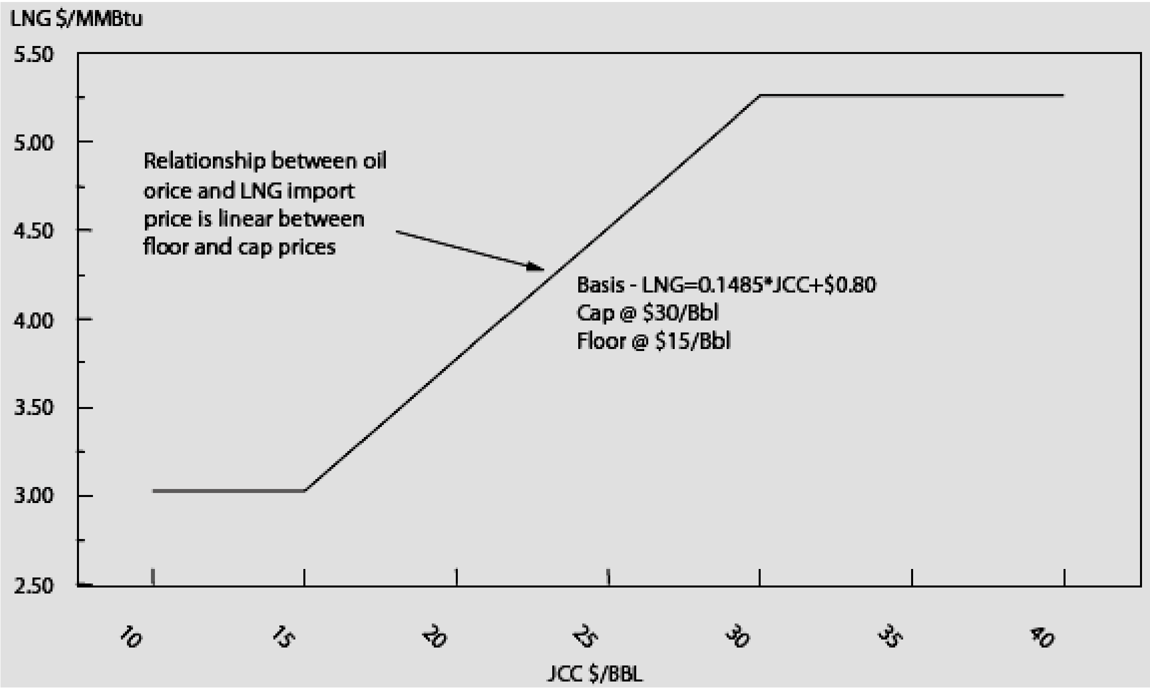
In the Pacific Basin, Korean and Japanese domestic gas markets developed on imported LNG. There was no domestic or pipeline gas supply to compete with LNG in Japan, but crude oil was the main alternative to natural gas in power generation[603] in the 1970s and early 1980s. As a result, LNG imports were referenced to movements in the prices of Japanese crude oil imports – referred to as *Japanese Customs-cleared Crude (JCC)* price.[604] So, when Korean and Taiwanese imports began, they priced off the JCC because it was the dominant market indicator.[605]

As LNG trade evolved, in a bid to counter the price floor concept[606], some buyers argued for price cap as protection in times of rising energy prices. The price floor and cap arguments resulted in the '*S' curve* concept (illustrated in Figure 3.11). This principle was created "*to soften the curves of escalation between the floor and*

[600] Roberts, P., *Effective Title Transfers in International LNG Trades*, Issue 7, I.E.L.T.R., 2007.
[601] These LNG price determinants are also affected by weather, storage, and other domestic market fundamentals (like domestic production capacity, investment, inflation, exchange rate and government policies).
[602] This consists of indexation formulas; as well as, a mix of alternative fuels and adjustment factors.
[603] Just as in Europe.
[604] JCC (sometimes called Japanese Crude Cocktail) is the average price of crude oil imports cleared by the Japanese customs.
[605] To date, LNG imports to these markets are typically referenced to movements in the JCC.
[606] Minimum price required to meet project financing obligation (discussed in 3.2.1).

ceiling through adjustable escalation rates that decline as the lower and upper limits are approached and that increase within an intermediate band."[607]

Figure 3.11 Illustration of the S-curve concept as used in Japan[608]



This concept, which originated in Japan, was applied predominantly in Asia Pacific, but has now been abandoned.[609] As discussed in Chapter Two, LNG trade globally has traditionally been influenced by the size of these markets, as well as, their price regime. For instance, in the period 2007-08, Asia Pacific LNG pricing significantly affected the Atlantic Basin LNG market. So, Chapter Six of this work captures the extent of this impact in relation to the uniform pricing concept.

b) North America

For two historical reasons, in North America, all gas (including LNG) imports[610] (long term and spot) are indexed to the price of NYMEX gas futures deliverable at the Henry Hub. The first reason is because the US gas market is very competitive, organized and liquid. Second and more important, North American gas markets

[607] Miller, P., *The Chain of LNG Project Contracts*, in Greenwald, G. (Ed.) Liquefied Natural Gas: developing and financing international energy projects, 1998.
[608] Source: James Jensen
[609] Platts European Gas Daily, *European gas prices challenge Asian*, Vol. 13, Issue 67, 7th April 2008 at http://www.platts.com/
[610] Irrespective of whether they are spot or long term contracts.

developed on indigenous resources and overwhelmingly on pipeline gas, before they began importing LNG. So, LNG has always been a marginal part of the market and competes with domestic pipeline gas supplies[611]. As a result, imports are referenced to prevailing gas prices, and invariably, the markets' evolutionary path has affected LNG pricing logic. Examples[612] of LNG netback pricing formulas for US spot or long term import (DES) are:

P_{LNG} = [NYMEX * 85% – Discount] or

P_{LNG} = [NYMEX * 90% – Discount] x (1-**R**) or

P_{LNG} = [NYMEX * 95% – Discount] x (1-**R**) - BD

where:
P_{LNG} – the LNG price in US dollar *per mmBtu*

NYMEX – NYMEX Henry Hub natural gas futures contract price

Discount - $(0.25) *per mmBtu*

R – Boil off losses at the regasification terminal (also called shrinkage) assumed as 1.5% of NYMEX

BD – Basis Differential between HH and the point of sale (local gas hub)

Just like pipeline gas transactions at various Hubs, LNG price at each terminal is derived from Henry Hub price by allowing for a 'fixed regasification charge and a basis differential'[613]. The underlying price and basis risks – consequence of hub-based pricing - also apply to LNG imports. Developments in LNG trade between 2007 and 2008 have raised doubts about exporters' confidence in hub-based spot prices (HH or NBP) as efficient bench mark for LNG in the Atlantic Basin. These notable developments, which led to significant premiums above the Henry Hub,[614] are extensively discussed in Chapter Six.

c) Europe

Gas markets across Europe were built on domestic supplies and/or imports from neighbouring gas-producing countries – like Norway, United Kingdom, The

611 This includes shale gas and imports from Canada.
612 Roberts, P., Presentation at LNG Pricing Workshop, IQPC London, March 2006.
613 Relative to the Henry Hub: as at 2004, the charges were $0.35 and $0.10 respectively for the US Gulf Coast.
614 Fesharaki, F., *Asian, global LNG Markets in transition are defining future*, Vol. 4, Issue 3, LNG Observer , July 01, 2007 at http://www.ogj.com/display_article/297536/94/ARTCL/Display/IsTrT/Asian,-global-LNG-markets-in-transition-are-defining-future

Netherlands and FSU. Then imported gas was used, as a substitute for oil products, mainly for space heating and power generation. Consequently, imported gas either competed with domestic gas or oil products but in some cases, had no substitute. Because LNG is seen as another form of imported gas, it has been priced as such – off competing fuels and/or by-products. Generally, netback market value approach is used to determine prices but the regimes for long term LNG contracts vary across Europe. Spain and the UK are exceptionally different from Continental Europe.

Spain

Spain's domestic gas market is not purely competitive but could be referred to as 'managed' or semi-competitive. It is termed 'managed' because the government directly/indirectly oversees most pricing issues despite the freedom of choice and entry. Due to Spain's geographic location and small gas domestic production, the market emerged after its Western European neighbours. Given their limited options (from Algeria and via trans-Pyrenees pipeline)[615], LNG imports are around two thirds of Spain's total gas demand.[616] Consequently, LNG is priced in some kind of "special" way and not as other gas imports. Initially, long term LNG was priced off oil products but it now indexed to either Brent crude price or the Henry Hub price - depending on demand levels and the need to attract more cargoes.

The **UK** has a competitive natural gas market, as described in section 3.1.2.5 above, and so LNG imports are not specially priced. Rather, like in the US, long term LNG imports are indexed to the price of NBP natural gas futures contract traded on the ICE (similar to NYMEX). The ICE natural gas index is the rolling arithmetic average of the daily volume-weighted front price. Based on the *front month futures contract* price, it is also the 'spot price' upon which a large percentage of pipeline and LNG contracts are priced[617]. Spot cargoes are priced either at NBP, fixed or indexed to a basket of NBP, oil products with a fixed component.

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[615] IEA, *Development of Competitive Gas Trading in Continental Europe*, Information Paper, 2008 at http://www.iea.org/textbase/papers/2008/gas_trading.pdf

[616] Spain's 58bcm per annum regasification capacity makes it the third largest LNG importer in the World. Figure 2.14 in Chapter Two shows a vivid picture of LNG's role in the Spanish gas market.

[617] Wright, P., Gas prices in the UK, p.68, para.2, (2006)

An example is given in the box below:

$\mathbf{P_{LNG}} = [(\mathbf{P_{ICE}} * 90\%) – \text{Discount}] \times (1-\mathbf{R})$

Where:
$\mathbf{P_{LNG}}$ = the LNG price

$\mathbf{P_{ICE}}$ = ICE NBP Hub natural gas futures contract price

Discount = (negotiable) in p/therm or USD per mmBtu

R = Boil off losses at the regasification terminal

Continental Europe

"*A major share of the international (gas) contracts in force on the European continent largely remain indexed either directly to the price of petroleum products, or indirectly through the use of crude oil netback prices*"[618]. Specifically, through their national champions[619], the four biggest gas markets (excluding the UK and Spain) index their LNG imports to petroleum products prices. Due to the inherent short term economic benefits, LNG importers in these markets could maintain this pricing pattern for a while. A typical European long term LNG pricing formula would reflect both direct and indirect substitutes[620] as:

$$\mathbf{P_t = P_x [n(G_t/G_x) + b(O_t/O_x) + c(C_t/C_x)]}$$

Where: $\mathbf{P_t}$ is the price of LNG at time t**,**

$\mathbf{P_x}$ is the price of LNG at time x; $\mathbf{G_t}$ is the price of Natural Gas at time t,

$\mathbf{G_x}$ is the price of Natural Gas at time x; $\mathbf{O_t}$ is the price of fuel Oil at time t,

$\mathbf{O_x}$ is the price of fuel Oil at time x; $\mathbf{C_t}$ is the price of Coal at time t,

$\mathbf{C_x}$ is the price of Coal at time x,

The coefficients n, b and c determine the weights and impacts of the respective fuels - natural gas, fuel oil and coal - on the contract price of LNG at any time t.

[618] Chabrelie, M. F., *Gas price indexation and strategies: A European Market perspective*.
[619] Germany's Ruhrgas; the Netherland's Gasunie; France's Gaz de France; Italy's Eni, - These are the incumbent national gas companies that have been partially or fully privatized. Despite the drive towards EC's Directives on gas markets, these companies are indirect monopolies in their domestic gas markets.
[620] Prices for pipeline natural gas contracts are indexed to a weighted average of the prices of other competing fuels – basket of petroleum products and coal. Fundamentally, natural gas is the direct competing fuel to LNG.

In some other parts of Continental Europe LNG Sales Contracts are indexed to petroleum products[621] prices but the Title Transfer Facility (TTF) and Zeebrugge Hub prices are also used. Generally, different bases of indexation are applied in LNG trade but prices are determined through netback indexation formulas. The difference in pricing regimes is, essentially, traceable to the regional development of natural gas trade. Consequently, to a large extent, the indexation principle reflects "the price movement of the competing fuel from the purchaser's point of view"[622].

Conclusion

It is apparent that the pricing and risk-allocation mechanism, in LNG trade, represents a dilemma and no standard model has been developed globally. Arguably, this is because the markets are different in different parts of the world. Unless there is increased transparency and exchange of trade information across markets, we may not see a single market price for LNG.

Perhaps, competition for LNG across Basins[623] has confirmed the producer dilemma by creating a new paradox in the pricing of LNG. Exporters want a price that is not significantly different from those obtainable in other LNG import markets, while importers want prices that are competitive in their markets or for arbitrage.[624] Meanwhile, no defined relationship exists between spot prices and long term contract prices.

The foregoing, therefore, portends the need for another pricing regime capable of reflecting a robust and more competitive market for gas (especially LNG). In sum, the following considerations would be vital for price determination as LNG trade evolves:

- The basis for price indexation should not be open to manipulation (i.e. uniform, transparent and neutral)

[621] Mainly high sulphur fuel oil; low sulphur fuel oil; as well as; electricity and coal prices.
[622] Griffin, P. and Smith, H., (Ed.) Liquefied Natural Gas: The Law and Business of LNG. P.8, (London: Globe Business Publishing Ltd; 2006).
[623] While demand in the Atlantic Basin is increasing gradually, spot LNG trade in the Pacific Basin is much more active.
[624] This option that is available to LNG buyers is disadvantageous to exporters.

- Pricing must progressively evolve to satisfy increasing spot trade and market liquidity by recognizing the effects of prices in other importing markets[625]
- The indexation of LNG to multiple price indices across regions is certainly not compatible with the globalization of LNG trade.

3.3 UNIFORM PRICING

Available literature indicates that a reasonable number of studies, on gas price movements and relationships within the Atlantic Basin, have been undertaken. Some of these efforts include De Vany and Walls 1993; Shook and Jaffe 2001; Hirschhausen 2003; Mazighi 2003/4; Jensen 2004; L'Hegaret et'al 2005; Ross 2004, Foss 2007; Stern 2007, as well as, Frisch 2008. These researchers questioned individual pricing concepts or attempted to explain the pricing principles or forecast LNG price path but little or no consideration was given to the interraction of regional pricing mechanisms and the implications for global LNG trade.

3.3.1 Definition of the Problem

The following quote, from a publication of the Energy Charter Secretariat, indirectly hints at the problem: "*The concept of a uniform international approach to LNG pricing may be a theoretical ideal, but it is far from a reality in current LNG markets*".[626] Given that "LNG is the mechanism for transmitting pricing signals around the world"[627] it is pertinent to ask whether having various bases for indexation is efficient for global LNG trade. Taken together, how well do these mechanisms enhance price discovery along the value chain? The need for a suitable LNG price regime is evident[628] and a primary challenge, therefore, is to reconcile the various bases for price indexation (Natural Gas Price at H/H, NBP and TTF; Price of Coal, Crude Oil Products and Electricity).

Various arguments may be put forward for or against each of the pricing principles/practices described above. This is because there are inherent risks,

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[625] That is the seller's perspective of replacement value.
[626] Energy Charter Secretariat, *Putting a price on Energy*, March 2007, p.188 at http://www.encharter.org/fileadmin/user_upload/document/Oil_and_Gas_Pricing_2007_ENG.pdf
[627] Jensen, J., *Increasing Global LNG Investments* -- A Presentation to the North American LNG Summit 2007 – Houston June 20, 2007 at http://www.jai-energy.com/pubs/NOAMLNG.PPT
[628] This is obvious from the rising number price disputes, renegotiations and arbitration. *See* Frisch, M., LNG market may soon see emergence of regular auctions for spot cargoes. LNG Journal, April 2008.

relating to each pricing principle, which importers and exporters try to transfer or mitigate. Conceivably, the bargaining powers of importers and exporters would continue to shift, as oil price rise and fall, to alter the international gas pricing regimes. While, long term contracts ought to incorporate a forward price curve, none exists at the moment. Neither do the regimes objectively define the worth of future gas supply nor how to place a price on long term gas supply. Besides, inherent economic interests in the prevailing price regimes may also hinder the systemic emergence of another price regime for LNG. So, the following sub-section attempts to answer the question: What principles would underlie a uniform pricing mechanism for LNG in the Atlantic Basin?

3.3.2 Proposition

Uniform LNG pricing would be an agreement to index long-term sales contract to crude oil price using, basically, the same formula. It is a system in which all LNG exporters apply, essentially, the same principle to determine the long term delivered price payable by buyers. It is a formal price-fixing agreement with the aim of *keeping prices higher than would have been*.[629] By applying such a model contract pricing formula, they could also aim to standardize upstream LNG pricing regimes within and across regional markets.

For the purpose of this exercise, it is proposed that Exporters will adopt a combination of WTI and Brent Crude-linked pricing in an addictive formula: $\mathbf{P_{LNG} = A + bY + \mu}$.

Where **A** is the standardized transport cost element[630]; the basis of indexation (**Y)** is the average Brent-WTI Price; **b** is the coefficient of indexation (**COI**)[631] and **μ** is exporter's share(**r)** of any arbitrage-resulting rent ($\mathbf{M_d}$). The COI (**b)** is chosen here

[629] This assertion is reinforced by the fact that producer-groups generally maintain a minimum price level above which prices are allowed to fluctuate. *See* Alhajji A.F. and Huettner D. *OPEC and other Commodity cartels: a comparison*, Page 1155, Vol. 28 Energy Policy, (2000).

[630] Exogenously determined and a function of the distance from exporter to importer (difference in distance if ***swap*** occurs): Typically the shipping industry has specific rates for specific Dead Tonne Weights for specific destinations.

[631] The variables and data used to create the Formula are defined extensively in Chapter 4.

as 0.1717[632]. Gas Exporters' preference for crude oil price indexation is an open secret. For example, about seventy percent of Algeria's long-term LNG sales contracts are index to oil.

3.3.3 Underlying Argument

Theoretically, gas has two price components: Production cost component borne by producers and substitution cost by the consumers. An agreement to exogenously determine price could enable exporters to exploit the substitution cost of end users rather than competing to produce at least cost as price rise. Such an agreement could be the mechanism for exporters to reap the resultant margin[633], rather than let importers (wholesalers, local distribution companies or end-users) have it. This is economically rational because higher natural gas (oil) price(s) accelerate investments in domestic resources and/or increase LNG importation.[634]

This author, therefore, proposes a uniform LNG pricing principle for long term LNG sales contracts based on oil-gas price relationship. A reason for this is that the value of oil is not equitably reflected in long-run LNG sales contracts.[635] Arguably, uniform oil price indexation may not be a more efficient[636] price determination mechanism but it could reduce the adverse affects of volatility on exporters and importers, as well as, eliminate the effects of refining capacity[637] on LNG price(s). Although gas rarely competes in the transport sector[638], oil price linkage is suggested here because it yields higher prices and long term LNG profitability for exporters.[639] In other words, the proposed formula can keep LNG prices relatively higher than would be - an economic incentive for exporters. It, however, transfers developments in the oil market to wholesale gas prices in the importing markets.

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[632] Simply the reciprocal of 5.825 mmBtu (energy content equivalent of a Barrel of Oil): Previously, a Rule-of-Thumb used for determining natural gas price in the US. Research indicates that it overstates the price of natural gas.
[633] That is 'Super-normal Rent/profit' discussed in section 3.1.1 above.
[634] This depends on the cost of exploiting gas resources or available import terminals in each market.
[635] This makes the current price regimes relatively disadvantageous to LNG exporters.
[636] Despite the use of the netback pricing, indexation, and self-contracting, in this author's opinion, bilateral price negotiation in long-term LNG Contracts is inefficient.
[637] The indexation of LNG price to Crude products transmits the effects of refining capacity constraints on LNG price.
[638]Unlike oil that is used predominantly in the sector.
[639] Relative to oil, on an energy equivalent basis, LNG is significantly discounted in the Atlantic Basin due to hub-based pricing.

It is necessary to emphasize that the above pricing mechanism is not expected to resolve the highlighted pricing issues and neither is the only option. Rather, it is only proposed here as a medium for investigating collusive uniform pricing in LNG trade. LNG exporters could uniformly opt to apply three price formulae in every long term LNG contract as an alternative to PSMs. A second alternative to the proposition above is to uniformly apply an LNG Hub-based spot price, but exporters would prefer oil. A uniform pricing model based on LNG '*basis differential*' reflecting transport costs from Qatar to various regional markets is conceivable. Such differentials would be standard[640] for different tanker sizes to specific delivery points in each market – similar to the land-based differential within each domestic or regional market[641].

This option, however, requires the establishment of an LNG Hub in Qatar (Middle East) or anywhere else[642]. While LNG pricing could become more transparent in the process, the feasibility of a competitive LNG Hub, in the Middle East, also raises other pertinent questions.[643] Another choice could be the uniform adoption of a Master Sales Agreement without pricing formulas but priced on individual cargo basis. In effect, it would offer exporters the choice to renegotiate contract prices on short term basis. Though it seems more pragmatic, one wonders how rewarding it would be considering the significance of long term contracts in LNG trade. Chapter Four, therefore, sets the framework for determining the extent to which uniform pricing, as a mechanism for influencing LNG trade, is feasible.

[640] Denoted as '**A**' in the formula **-** typically the shipping industry has specific Dead Tonne Weights rates for specific destinations.
[641] An extensive explanation of *Basis Differential*, in the North American gas market, is available in Jensen, J.T., The Development of a Global LNG Market – Is it likely? If so when? 2004.
[642] The Hub does not need to be a producing region – it could be in Tokyo Bay.
[643] Some of these issues have been discussed in Wagbara, O., *To what extent is a liquid LNG Hub, in the Middle East, feasible?* I.E.L.R; Issue 3, 2008

CHAPTER FOUR

ATLANTIC BASIN LNG TRADE MODEL (ABLTM)

4.1 INTRODUCTION

4.1.1 Background

A model simply captures the vital characteristics of a real problem being investigated. The more accurate its representation of reality, the more useful it is and may be referred to as a valid model.[644] On the premise of the discourse in[645] Chapter Three, this Chapter simulates Atlantic Basin LNG Trade; applies the Uniform Pricing (UP) proposition and Volume Control (VC) mechanism in different scenarios to determine feasibility. A brief review of modelling literatures follows after this background, while the next two sub-sections define the Problem and Methodology for this Chapter respectively. The second section (4.2) describes the elements of the Model (Assumptions; Structure and Data), while section 4.3 covers the scenario analyses and presentation of results.

4.1.2 Literature Review

Some research have been undertaken to study gas price movements, relationships and strategies in different markets - De Vany and Walls 1993; Mazighi 2003/4; Jensen 2004; L'Hegaret et'al 2005; Neumann and Vasquez 2006; Neumann and Ruster 2006; Neumann 2007 (see full references in bibliography). Other researchers[646] have also designed models to capture the different aspects and future trend of LNG (and Natural Gas) trade both regionally and globally. Some of these models were reviewed in Chapter One (section 1.6) but more relevant cases are captured below.

In their EUGAS scenario model, Perner and Seeliger investigated the impact of a gas cartel on the European gas market. Adopting an OPEC-style production quota approach for the gas cartel, they concluded that the "fictive gas cartel would have significant impacts on gas supply costs for Europe".[647] Taking a different approach,

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[644] Ragsdale, C.T. Spreadsheet Modelling and Decision Analysis, para.1, p.4, 1995

[645] The evolution, principles and dynamics of pricing in international gas trade were discussed in Chapter Three.

[646] See Energy Journal, Volume 30, Special Issue, 2009.

[647] Perner, J and Seeliger, A., *Impacts of a gas cartel on the European gas market – selected results from the supply model EUGAS*, Volume 12, utilities Policy, 2004.

Aune et al also simulated a Middle East Cartel Scenario in a numerical model of international energy markets. They introduced a fixed export duty on gas, as a means of maximizing revenue, and discovered a minimal effect on gas prices until 2020.[648] While agreeing with the conclusion reached by Perner and Seeliger, the same can not be said about the results obtained by Aune et al. In fact, the outcome is not striking because with netback price determination, a fixed export duty would only reduce the margin accruable to exporters.[649]

Hayes simulated Atlantic Basin Gas Trade, using two models (linear optimization model run in GAMS and a Monte Carlo simulation run in MS Excel with the Crystal Ball add-in to determine the interaction of liquefied natural gas (LNG) trade with the fundamentals of pipeline gas supply, storage and consumption. Hayes' model was aimed at analyzing how growth in LNG trade provided opportunities for seasonal arbitrage using vessels and import capacity, as well as, the effects on gas markets in Europe and the US.

Hayes discovered that "LNG creates the means for spatial arbitrage that will interact with storage to effectively connect regional market prices over time".[650] Furthermore, "the net result will be price spreads between "integrated" competitive gas markets that vary on a monthly basis, driven not only by transit costs but also by differential costs of gas storage".[651] The simulation here is similar to Hayes' - both are month-scale Atlantic Basin trade models. While Hayes focused on demand-side issues (like domestic gas storage, transport cost and seasonal demand), here ABLTM dwells on supply-side LNG issues (pricing and market influence). Interestingly, Hayes emphasized that, irrespective of market type,[652] long term supply security would be determined by growth in LNG supply (investment).[653]

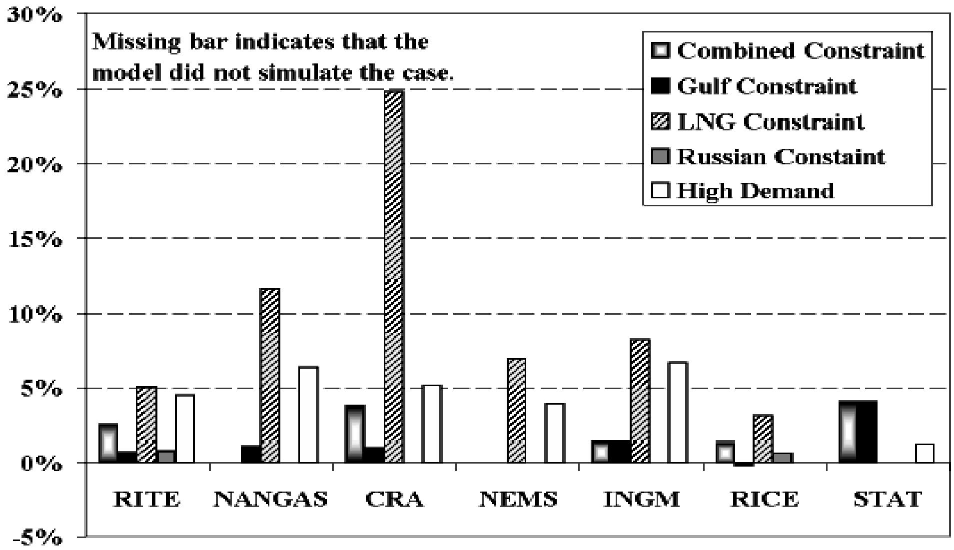
Meanwhile, Victor and Hayes assert that enduring regulatory regime, in LNG exporting countries, is the most relevant factor for attracting and increasing LNG

[648] Aune, F., et'al, G*lobalisation of Natural Gas Markets – Effects on Prices and Trade Patterns,* Vol. 30 Special Issue, 2009.
[649] But, it would have little or no impact on gas prices in the importing market.
[650] Hayes, H.M., Monthly Gas Trade in the Atlantic Basin circa 2015 flexible LNG supply, storage and price formation in a global natural gas market, Dissertation 2007.
[651] *Ibid*
[652] Whether managed gas markets (as in parts of Europe) or competitive gas markets.

investments.[654] These assertions are tenable but they ignore the pricing issues inherent in gas (especially LNG) trade – which this author considers most pertinent.[655]

Based on a set of standard scenarios and common input assumptions, eleven organizations[656] used different models to participate in **the** Stanford University's **Energy Modelling Forum** gas study **(EMF 23)**. The summary report, of the various modelling efforts, states that "*the long-run natural gas price path will move with world crude oil prices over the next two decades, although there is not a fixed relationship between the two energy prices*"[657]. Perhaps, it is notable that most of the models in the programme obtained almost similar or related conclusions.[658] So, the comprehensive report[659] has been reviewed here rather than analyzing individual studies/results.

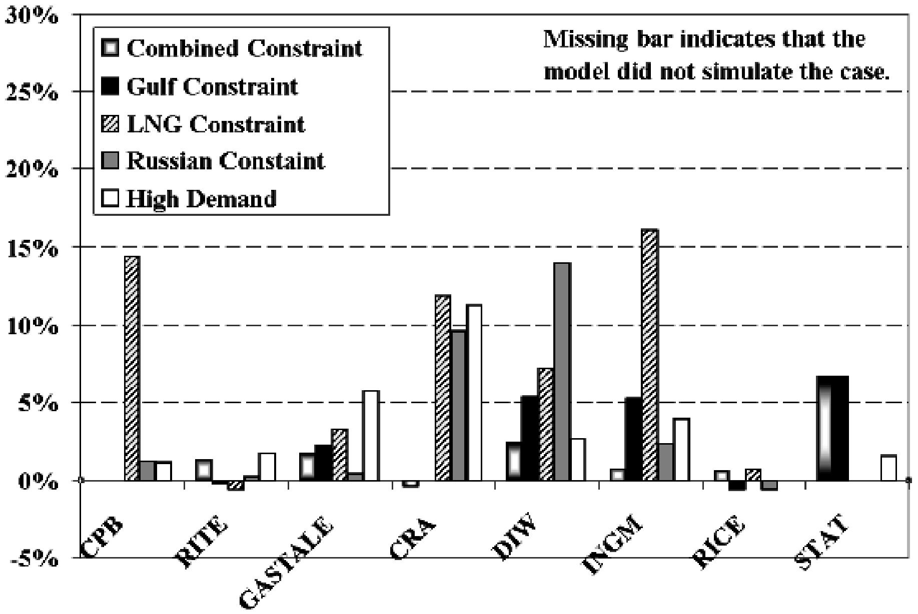
Figure 4.1 Delivered US Price increase in various constrained scenarios[660]



[653] Hayes, M. *Institutions and Gas market Security*, Dissertation 2007.
[654] Victor, D., and Hayes, M., P*olitics, Markets and the shift to Gas: Insights from Seven Historical Case Studies*, in Victor, D. et'al, (Eds.) Natural Gas and Geopolitics from 1970 to 2040, 2006.
[655] LNG trade is evolving and continually interacts with pipeline markets in peculiar ways – making it difficult for anyone to predict what prices would be.
[656] See list of Organizations in Huntington, H; *Findings of the EMF Study 23: World Natural Gas Markets;* Presentation at the 26th IAEE/USAEE Conference, Houston, TX September 18, 2007.
[657] Energy Modeling Forum (EMF), *Prices and Trade in a Globalizing Natural Gas Market*, EMF Report 23, Stanford University, July 2007.
[658] Perhaps, this was due to the fact that they had common objectives and used the same template.
[659] See report of the EMF 23 programme at http://www.stanford.edu/group/EMF/projects/emf23/emf23.pdf

It is noteworthy that the EMF teams also simulated constrained LNG supply scenarios.[661] Their results, as captured in Figures 4.1 and 4.2, indicate that prices were raised above their reference path.[662] Some of these models[663] constrained LNG trade by ignoring on-going liquefaction projects, while others imposed the constraint on regasification terminals. Two anomalies could be identified from both approaches.

Figure 4.2 Delivered W. European Price increase in the constrained scenarios



Source: http://www.stanford.edu/group/EMF/projects/emf23/emf23.pdf

First, expectations about on-going liquefaction projects exert downward pressure on gas prices in the importing countries. Because, long term LNG lacks a forward price curve, it is inconsistent to determine the inverse effect on price, by not considering such project. Second, due to limited activities, most import terminals in the US have been operating below installed capacity.[664]

660 See Energy Modeling Forum *Prices and Trade in a Globalizing Natural Gas Market*.
661 Some tested model response by constraining new liquefaction projects while others imposed constraints on regasification terminals.
662 Energy Modeling Forum, *Prices and Trade in a Globalizing Natural Gas Market*, EMF Report 23, Stanford University, July 2007.
663 In Figures 4.1 and 4.2, the horizontal axis shows the models used in EMF 23.
664 GIIGNL, *The LNG industry*, 2008

Consequently, a change in number of terminals (positive or negative) has absolutely no effect on domestic gas prices or LNG prices.[665] Rather, it is the amount of LNG imported (or available for import) that could affect prices. So, the volume control scenario (simulated here) fills both gaps by constraining LNG trade through a reduction in available contracted capacity[666] - while taking new liquefaction projects into consideration.

In sum, available literature indicates that most models have either investigated natural gas price convergence, integration of natural gas markets or convergence of LNG netbacks.[667] The model results (in the case of EMF 23) were not expressed relative to the size of LNG constraint in each importing market. Furthermore, neither of the models considered a uniform LNG pricing scenario, nor specifically captures the effects of an LNG exporters' cartel.[668]

So far, only Egging et al comprehensively captures the effects of cartel behaviour in the global gas market.[669] But, their World Gas Model (WGM) did not consider cartel stability and also downplays the peculiar nature of LNG pricing - which benefits regasifiers.[670] The WGM, however, reveals that "the cartel impact is particularly manifest in the LNG market". In contributing to the body of knowledge, this author adopts a novel approach, a regional scope and a shorter time frame (2005 to 2013).[671]

4.1.3 Definition of Problem

The question of feasibility, as mentioned in the introduction, is whether either mechanism optimally benefits exporters without significantly disrupting LNG trade.

[665] For instance, in 2008 US LNG imports dropped by 55% from the 2007 volume despite the opening of two new terminals – Freeport LNG (in Texas) and Sabine Pass (Louisiana).
[666] This method is more logical than the approaches adopted in EMF 23.
[667] These research efforts also had different scopes - within the Atlantic Basin or across the globe.
[668] Existing models considered cartel of pipeline gas exporters; Middle East Exporters; pipeline and LNG Exporters together or constrained LNG supply.
[669] Egging, R., et al., *Representing GESPEC with the World Gas Model*, Vol. 30, Special Issue, 2009.
[670] The World Gas model acknowledges this - market power lies with the regasifiers. Ironically, it seems to ignore an important issue - most LNG price regimes constrain the maximization of exporters' revenue (as explained in Chapter Three – Figure 3.3). Meanwhile, the approach of selling LNG via one single cartel regasifier is unrealistic given regasification capacity constraint – which also limits the amount of LNG importable at any time.
[671] Considering the emergence of new climate change policies and reductions in long term gas demand projections

Therefore, feasibility is attained if exporters have no incentive to cheat; demand destruction does not occur and LNG trade develops despite any influence mechanism(s) adopted. To test for feasibility, the model generates quantifiable[672] gains and losses to exporters in both UP and VC scenarios.

The author also aspires to determine the conceivable benefits or losses to exporters from uniform pricing or volume control. Given the assumptions, the model's simulation exercises are aimed at answering the following secondary questions:

- In what scenarios could uniform pricing or volume control be applicable?
- Could a uniform pricing regime be easier to implement than volume control?

4.1.4 Methodology

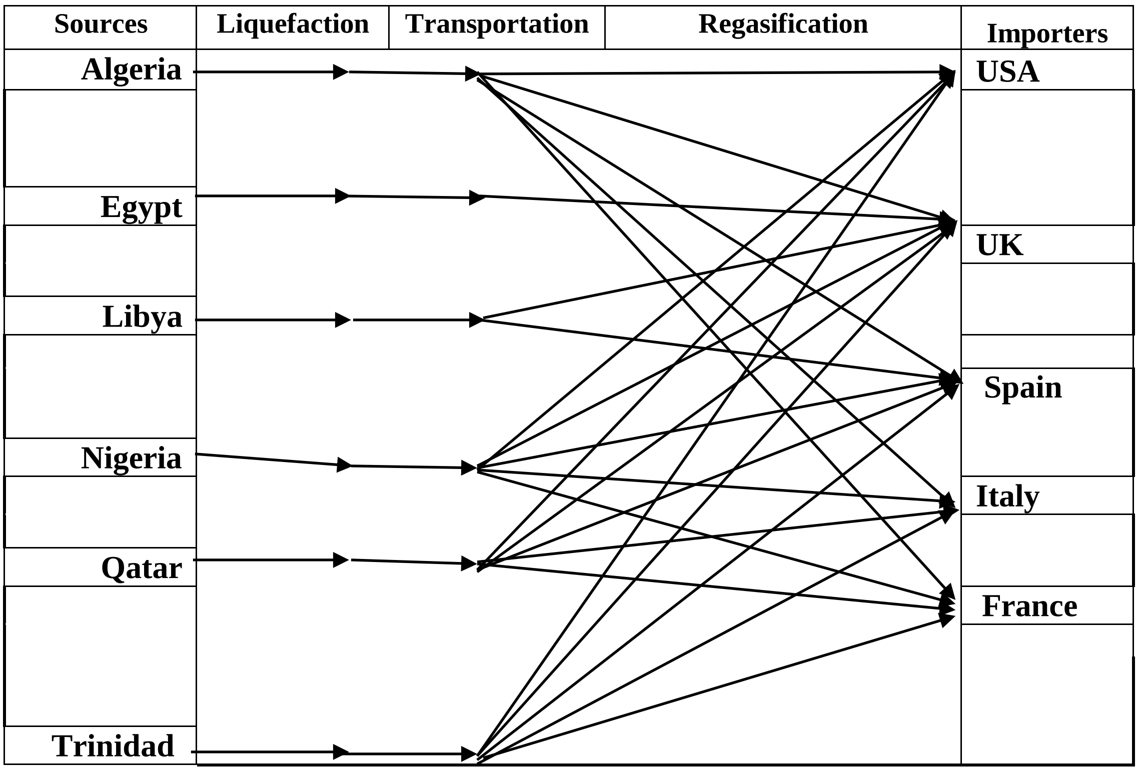
In their paper, David Bobrow and Robert Kudrle[673] assert that no single perspective can comprehensively cover the issues of an intergovernmental resource organization. This Chapter, therefore, combines statistical and descriptive analyses. Starting from the premise of a hypothetical LNG exporters' organization the author assumes that LNG trade could be collusively influenced. This assumption is based on the view that the emergence of a global gas market in an uncertain price environment makes collusion attractive[674] to exporters. Besides, it is a historical fact that cartels "are mostly feasible where they are least needed - where there are few sellers with high concentration".[675]

A simple spreadsheet model is built to capture some elements of Atlantic Basin LNG trade. With Palisade Decision Tools, six exporters and five importers are simulated using long term contract volumes, as well as, historical contract and spot (US and UK) prices. The revenue function of each benefit-optimizing exporter is used in a static 3-scenario simulation exercise to capture the effect of changes in some variable – Price (given/otherwise) and Contract volume (Supply).

[672] Revenue; export volume; and uncontracted (spare) capacity relative to the base case.
[673] Bobrow, D.B. and Kudrle, R.T., *Theory, Policy, and Resource Cartels,* pp. 3-56, Vol. 20, No. 1, The Journal of Conflict Resolution, March 1976.
[674] Although, it may be argued that, it also reduces the economic justification and drive for it.

Short term and long term perspectives are considered in the analysis. Short term, here, refers to the first twelve (12) months after the adoption of a market influence mechanism (UP or VC). Within this LNG (gas) supply cycle, it is assumed that, no response from importers is possible due to the strategic nature of the resource. Any other period after this LNG (gas) supply cycle (first year) is considered as long term. The base case could be viewed as the status quo in 2013. In other words, it captures current price trend and contractual volumes until 2013 (without any influence mechanism).

Table 4.1 Simulated LNG participating countries



Following from the base case, sensitivity analyses of different market-determining scenarios (uniform pricing proposition and volume control) are undertaken. Price elasticity of demand for LNG[676] is used as the link between Volume and Price in each consuming market. The model includes (Table 4.1) major exporters[677] and

[675] Bobrow, D.B. and Kudrle, R.T., *Theory, Policy, and Resource Cartels*, pp. 3-56, Vol. 20, No. 1, The Journal of Conflict Resolution, March 1976.
[676] From each importing gas market (apart from the US), the price elasticity of end use demand for natural is used as a proxy for the elasticity of demand for LNG.
[677] Algeria; Nigeria; Qatar; Libya; Egypt, as well as, Trinidad and Tobago

importers[678] in the region even though other Countries (plan to build) have regasification and liquefaction terminals.

The model has a regional scope but it captures inherent global implications in the analyses and interpretation. Given the lead-time of LNG projects, supply-side response to price changes is not captured in the simulation but it is considered (as a spot market issue) when interpreting the results. The context and structure of the model follows from the nature and infancy of LNG trade. This approach differs from others because it appreciates that LNG exporters may not collude globally but could operate, directly or indirectly, through uniform pricing or supply manipulation. It, therefore, emphasizes price-fixing on a regional scope because LNG prices vary regionally (but are defined and influenced by other inter-regional factors).

4.2 MODEL FRAMEWORK

4.2.1 Assumptions of the Model

- An Atlantic Basin World[679] with a competitive LNG market of relatively few sellers and many buyers (given the seasonal competition for LNG) and no destination (or use) restriction clause(s)
- LNG-exporting countries, in the Model, are assumed “firms” in an industry with:
    - very high concentration;
    - negligible product differentiation; and
    - high barriers to entry: given the huge investment requirements, strategic and exhaustible nature of gas (LNG)
- Exporters have the same Marginal Cost (MC), as well as, knowledge of the shape and position of the industry LNG demand curve: in other words, the same market information is available to all exporters[680]
- The Atlantic Basin LNG Trade Model **(ABLTM)** is a static representation of long-term LNG contracts[681] captured on a monthly scale
- **ABLTM** does not yield equilibrium[682] solution(s) but is meant to give insights

[678] Spain; Italy; France; U.K and the U.S
[679] This includes Qatar which, though situated in the Middle East, trades with Buyers in the Atlantic Region.
[680] The mutual exchange of commercial, technical and legal information is a fundamental benefit accruable to colluding exporters, even before an influence mechanism becomes effective.
[681] Spot LNG transactions are ignored in the simulation exercise but are considered in the course of interpreting and analyzing the model’s outcome.

- The principal objective of LNG Exporting Countries (individually and collectively as a group) is to maximize benefits (especially revenue) at any time in the course of exploiting their gas deposits;[683]
- The null (main) hypothesis is that given demand, uniform LNG pricing or volume control is feasible[684]
- Proposed price-setting formula is designed (in sub-section 4.3.1 below) to suit the research and to answer specific questions of interest;
- The same[685] LNG is sold destination-ex-ship (d.e.s),[686] in equal-sized vessels; no shortages of uncommitted vessels[687] and prices are assumed to reflect value and transportation cost;
- Shipping cost from one exporter to importer is assumed standardized[688] and a part of price, as well as, revenue: so no change in price or revenue results from change in transport cost;
- There is no significant difference in LNG import price across regasification terminals within each importing country;
- Each exporting country has only one liquefaction terminal
- Natural Gas or LNG Storage capacity is also assumed fixed[689] over the period covered in the Model
- LNG export volumes are based on existing and expected annual (monthly) contracts and assumed to run through out the modeling period[690]

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682 Petroleum (oil and gas) markets are rarely in equilibrium. For instance, OPEC's spare capacity; Strategic Petroleum Reserves; as well as, uncontracted LNG Liquefaction and regasification Capacities are evidence of this.

683 Although some Petroleum Exporters (like Saudi Arabia or Trinidad) prefer a reasonably even growth of revenue (rather than windfalls), the generalization is based on their common socio-economic (and political) needs.

684 Beneficial to Exporters but without a resultant 'demand destruction' or disruption to trade

685 That is in terms of quality (Sulphur; Hydrogen sulphide; Hydrogen and Oxygen content; as well as, other impurities).

686 100% of Nigerian LNG's long term contracts are delivered sales. For tax purposes, sales to the US are delivered (ownership is transferred) before entry into US territorial waters and termed CIF. As part of its agreement with the European Commission, Algeria's Sonatrach would transform all existing FOB and CIF sales contracts to D.E.S. See EUROPA, *Commission and Algeria reach agreement on territorial restrictions and alternative clauses in gas supply contracts*.

687 Given the number of non-dedicated vessels under construction and free entry into the shipping industry, capacity is assumed sufficient.

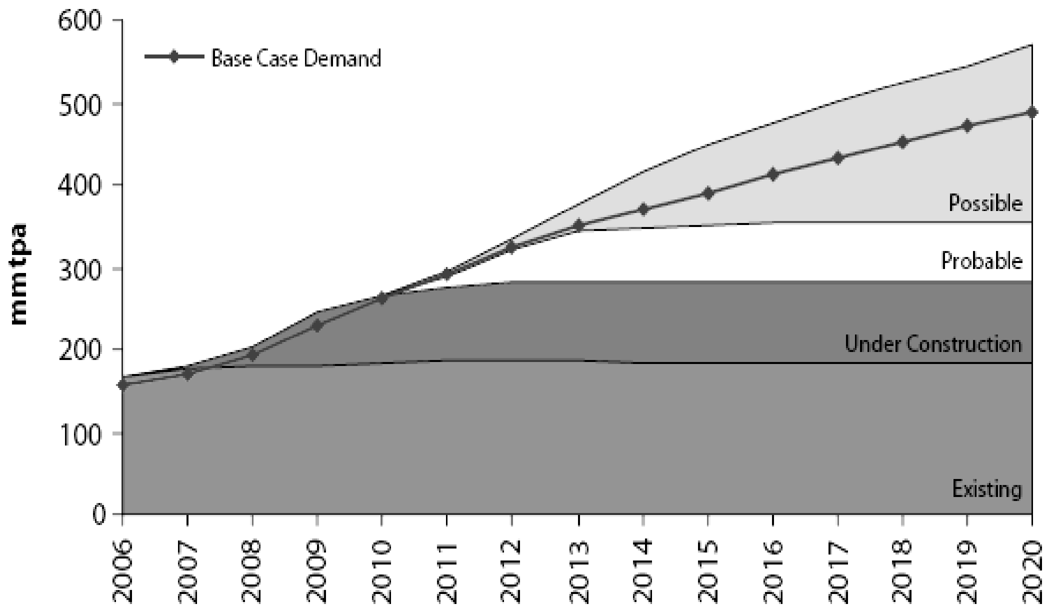
688 The basis for this assumption is described extensively in Appendix 3.

689 This author appreciates that weather and storage costs are important factors that affect LNG demand and price formation in most domestic markets in the Atlantic Basin.

690 The model covers contracts running until 2013.

- Exporters' market share is defined by existing[691]contracts and capped by their liquefaction capacity (at 95% of their nameplate capacity[692])

Figure 4.3 Potential Global LNG Supply Vs Demand (2006-2020)[693]



- Demand for LNG exists (as Figure 4.3 shows) in the five countries of interest and there is sufficient capacity[694] to regasify the contracted volumes
- Demand is inelastic with respect to price in the short term (**Base Case)** but changes in different scenarios

4.2.2 Data Description and Model Specification

Most of the data (Contract Volumes and Prices) used in the simulation were extracted by author from Gas Strategies Database.[695] Gas Strategies is a Consultancy which provides services to Companies in the LNG industry and provided the data on the grounds they would be used confidentially. As such, the data is reliable to the extent that it was sourced from a reputable organization in the industry. To mitigate this shortcoming, the accuracy of some data was verified by comparing them with data from the trade press. Meanwhile, Appendix 3

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[691] Including on-going constructions capacity expected by 2013
[692] In reality, however, actual capacity could be about 85% - due to operational problems with feed-gas supplies; liquefaction plants and host community issues.
[693] Harris, F. and Law, G., *Seller's market for LNG set to last*, A Perspective from Wood Mackenzie.
[694] Currently the US and Spain underutilise their regasification capacity.
[695] See www.GasStrategiesOnline.com

systematically lists most of the data (non-confidential) used in the simulation exercise.

The author simulates Atlantic Basin LNG trade involving six exporters and five importers in a simple spreadsheet model. The objective function[696] is defined in the Base Case as the product of Average Monthly Contract[697] Volume and simulated[698] Price. Changes in the revenue variables – price and contract volume - are captured and analyzed subsequently. Simulation and scenarios analyses enable the author to compare each Exporter's situation within and without a mechanism (Uniform Pricing or Volume Control).

The following defines the simple model:

$$\underset{Q_{ei}\geq 0}{Revenue} = \sum_{e=1}^{6}\sum_{i=1}^{5}(P_{ei})Q_{ei} \qquad \text{Objective Function}$$

$$\text{Subject to} \sum_{i=1}^{5} Q_{ei} \leq Liq_e \qquad \text{Supply Capacity Constraint}$$

$$\text{for every importer (i),} \sum_{e=1}^{5} Q_{ei} \leq Reg_i \qquad \text{Regas Capacity Constraint}$$

$$Q_{ei} \geq 0; P_{ei} \geq 0; t_{ei} \geq 0 \qquad \text{Non-zero considerations}$$

Where:

P_{ei} = Price paid for 1mmBTU of LNG contracted/sold destination ex-ship (d.e.s) by exporter '**e**' to importer '**i**' (and unit[699] transportation cost is assumed part of it)

e = Exporters (e = 1, 2, 3…6); **i** = Importers (i = 1, 2, 3…5)

Q_{ei} = Trade (*actual* Volume delivered by (e) to (i))

Liq_e = Exporter (e)'s Liquefaction Capacity and

Reg_i = Import (i)'s Regasification Capacity

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[696] Total revenue function of each benefit-optimizing exporter.

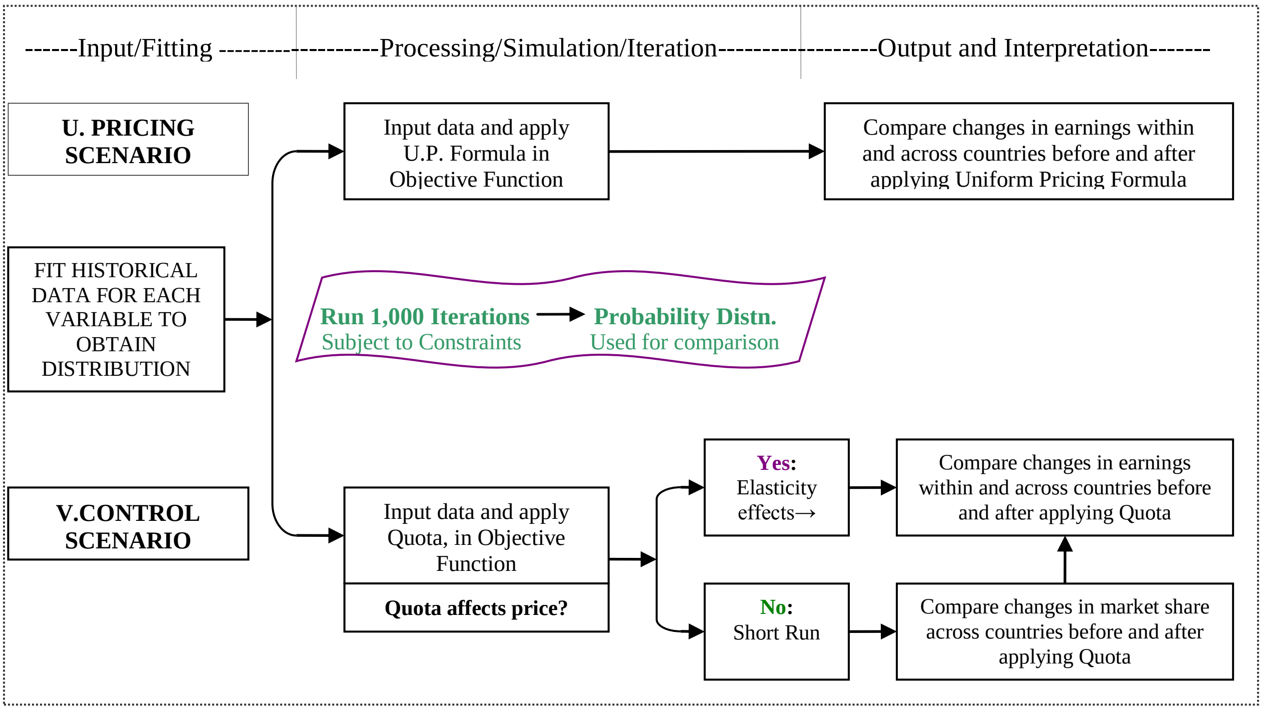
[697] Future LNG contracts up to 2013 have been captured and to allow for spot transactions, contractual obligation is not a constraint to revenue maximization.

[698] To allow for Simulation: Palisade *Decision Tools* software (@Risk) generates the fit for the historical data and simultaneously creates a distribution function used in *Excel* to simulate, compare and analyze variables. It permits the definition of all uncertainties related to all the input variables and determines the likely range of outcomes for each output variable in a probability distribution.

[699] Generally, in the Atlantic Basin, shipping cost ranges from 55 to 86 cents per MMBTU over a nautical mile. For example, Nigeria to the UK costs about 86cents; Algeria to Spain is about 55cents while Qatar to the UK is about $1 per MMBTU.

Specifically, inputs in the Model are Average Monthly Contract Volumes[700], historical LNG Prices for Spain and France; historical Brent and WTI Crude Prices; Henry Hub and NBP[701] natural gas prices. Due to the unavailability of actual contract pricing formulas, spot prices (NBP for UK; H/H for USA; and TTF for Italy and France) are used as proxies for actual contract prices. Spot natural gas prices are the closest substitutes for LNG long term contract prices but they have the tendency to make the revenue data more volatile. The impact of this limitation was reduced by using @Risk to fit the data.

Figure 4.4 Schematic diagram of ABLTM[702]



With different iteration results in each scenario (see Figure 4.4), the model's outputs are: LNG prices (specific and uniform); change (%) in Price and Revenue. Other exogenous inputs considered are shipping cost per distance per MMBTU;[703] Gas Storage Data for each importing country; LNG demand projections; liquefaction and regasification capacities.

[700] Total Annual Contracted Volume divided by 12.
[701] Used after conversion from p/th to $/mmBtu using: 100,000 Btu = 1 Therm and monthly exchange rates.
[702] Chapter Five then addresses how the quantitative outcome fits into each exporter's gas context and export strategy.
[703] This was useful in arriving at an assumed value for transportation in the U.P Formula.

In the **Model's Base Case,** LNG long-term contracts[704] reflect the monthly revenue portfolio and market share of each exporter. Mean Prices[705] are generated through several iterations[706] using Latin Hypercube. This process uses the entire distribution of historical prices rather than running regression to estimate price equations for each exporting country. It is also effective for forecasting future prices using past behaviour. *"For example, because the price of natural gas tends to fluctuate with the season, periodic price data gathered over several years can be used in modeling future price variations for that fuel"*[707]. Furthermore, the iteration process automates the random selection of scenarios. By using the same SEED numbers for iterating, the input clusters are chosen evenly across the variables and so the outcomes converge.

4.3 SIMULATION EXERCISE

Two hypothetical scenarios of trade influence are simulated. Subsequently, in each scenario, the model solves for prices and generates a mean price for each exporter to generate simulation results. First, the Uniform Pricing proposition and then the Volume Control option follows. Given its assumptions, each subsection begins with a background that describes its peculiar market scenario.

4.3.1 Uniform Pricing Scenario

Exporters uniformly adopt a combined WTI-Brent crude oil-linked pricing formula[708] for their long-term LNG contracts. For the purpose of simulation and analysis, it is assumed the Group determines LNG price at ($X per BTU) by applying the following additive[709] formula:

$$\mathbf{P_{LNG} = A + bY + \mu}$$

Where: **A =** Fixed component of Price[710]

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[704] 1996 to 2013: sourced from Gas Strategies Online UK, Global LNG Database
[705] Given the assumption of sales destination ex-ship (d.e.s)
[706] By using *Palisade* Decision Tools to run **Best-fit** on historical LNG contract volumes and prices.
[707] Palisade, KnowledgeBase: *Create a Distribution from new Results* at http://helpdesk.palisade.com/kb/masterFrame.asp?http://helpdesk.palisade.com/kb/article.asp?ID=675
[708] Defined based on the principle proposed in Chapter 3 above
[709] LNG Price formulas may either be additive or multiplicative but for simplicity, a linear relationship between LNG Price and Oil is assumed.
[710] Sufficient to cover cost of feed gas but, in this work, it is assumed equal and fixed for all exporters. Hence, its value does not affect the outcome.

Y = $\left(\frac{(Brent+WTI)}{2}\right)$(i.e. average Brent and WTI Prices)

b = 0.1717[711]

μ = r*M_d

The fixed component '**A'** in the formula covers the unit cost of feed gas and transportation cost. The transport element is assumed exogenously determined[712] and a function of the distance from exporter to importer (or difference in distance in the case of a ***swap***[713]). On the average, unit cost of transporting LNG per distance change only when larger vessels, which yield economies of scale, are used. In this exercise, given the specific-sized vessel assumption, transport cost per distance is fixed.[714]

M_d is the margin (rent or profit) consequent upon arbitrage/diversion of an LNG vessel; while **r** is the proportion (of the margin - **M_d**) accruable to each exporting country. The variable **μ** ensures that exporters capture arbitrage rent. In a world of increasing flexibility, **μ** (especially the ratio 'r') is the mechanism that would ensure Uniform Pricing does not hamper or discourage arbitrage. As the Profit Splitting Mechanism (PSM)[715], it would, motivate both importers and exporters to seek[716] arbitrage opportunities for their mutual benefit (since the off-taker gets (1-r)). In the short term, for instance, price differentials are caused by changes in demand/supply; weather (seasonal) or storage capacity and so do result in arbitrage.[717] On long term basis, a 20% premium above Henry Hub (HH) netback could be enough incentive for LNG diversion eastward (across the Atlantic or to Asia) by an exporter.[718]

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711 Derived from the 6 to 1 Rule-of-Thumb and the coefficient of Brent-WTI Crude Oil Prices

712 Typically the shipping industry has specific rates for specific Dead Tonne Weights for specific distances or destinations.

713 To avoid cross-shipping and reduce transport costs exporters (and other counterparties) sometimes use swap agreements.

714 The transport cost to each regasification terminal is available from Gas Strategies Online, UK.

715 Generally, the industry considers Profit Sharing a fairly convenient mechanism for the allocation of arbitrage rent. Currently, with a PSM clause, buyers and sellers share the margin, after deducting any extra costs of diverting a cargo. Such PSM clauses also contain provisions that allow for independent confirmation of secondary price(s) (if considered non-transparent).

716 Irrespective of the nature of the sale (whether FOB, CIF or DES).

717 Not considered in the simulation exercise below

718 Fesharaki, F., *Asian, global LNG Markets in transition are defining future*, Vol. 4, Issue 3, LNG Observer, July 01, 2007.

Meanwhile, crude oil prices are simulated using a 6-0-2 escalation formula: six-month-average; zero time-lag and rolled over every two months. The six-month average evens out seasonal price fluctuations and so the underlying effects on price are ignored in the simulation exercise. The coefficient '**b'** equals one-sixth of the referenced indices and determined by applying the energy content principle (or simply 6-to-1 Rule of Thumb). So for every Brent-WTI crude oil price of $60, **Y** equals $10.

Previously, simple Rules of Thumb[719] have been applied in forecasting prices through the relationship between crude oil and natural gas prices. Developed by observing prices, the rules fairly described 1990s oil-gas price relationships in the US. When assessed with Henry Hub gas prices, for the past 20 years, results revealed that the 10-to-1 rule consistently under-forecasts, while the 6-to-1 rule consistently over-forecasts natural gas prices.[720] Adopting the energy content principle (6-to-1 rule) in the Uniform Price Formula[721] for LNG contract price determination yields some interesting results. A casual observation of LNG prices from 1998 to winter 2005 (gas price hikes) reveals that the formula generally tracks Algerian, Spanish[722] and Italian long term LNG contract prices.

Theoretically, the formula consistently captures the co-integrated relationship that exists between oil and natural gas[723] in the domestic markets. Therefore, when oil price is rising (falling), LNG could still be price-competitive relative to oil products and pipeline gas, provided crude oil price remains fairly[724] high. Generally, however, when domestic natural gas prices are low, the determined price of LNG could be

[719] In the US, the 10-to-1 rule was used initially to forecast natural gas price. Later the 6-to-1 rule emerged to reflect the 5.825MBTUenergy content of a WTI barrel of oil. Japanese LNG Importers still apply some variations of these rules against the Japanese Crude Cocktail (JCC) for price determination in spot deals and Long term contracts.

[720] Brown, S.P.A. and Yucel, M.K., *What drives natural gas prices?* Research Dept., Federal Reserve Bank, Dallas, Working Paper 0703. February 2007.

[721] That is the coefficient '**b'** in the formula defined above.

[722] Spain is the largest importer of gas in the Atlantic Basin and did set the LNG price for Europe in 2005/6 winter seasons. *See* Frisch, M and Lapuerta, C. *Price shocks reveal trends in Atlantic Basin Markets*.

[723] The end-product of LNG

[724] That is *price which the market can bear* - *consumers are able to pay*- *and high enough not to erode future demand within the global economic context.* For further discourse on this, see Alhajji, A.F., *What is the 'Fair' Price of Oil*?

higher.[725] The Formula, therefore, ensures that domestic natural gas prices (pricing regimes/policies) and storage levels would only affect spot LNG prices. So, rather than cheat in a uniform pricing set-up, exporters could gradually increase the volume of their spot deals to gain from demand-pull or volatility-induced arbitrage.

4.3.1.1 Scenario Specific Assumptions/Inputs

- The Uniform Pricing Formula (defined above) is applied to determine a (minimum) price ($X) for all Exporters and adopted in all existing contracts[726]
- From the medium to long term, LNG demand is elastic;
- The price elasticity of demand for natural gas, in each European market, is adjusted to determine the index for LNG;
- From Holz et' al[727], the following elasticity indices (ψ) for natural gas demand were determined for the European importers: France(-0.70); Italy(-0.75) Spain(-0.65); and UK(-0.70)[728]

Table 4.2 Natural Gas Consumption (Bcm) vis-à-vis LNG Trade movements in 2006

To↓	Total LNG Imports	Gas Consumption[729]	LNG as a % of N.G	Nat Gas Elasticity	LNG Elasticity
USA	**16.56**	619.7	2.67%	0.90	0.02
France	**13.88**	45.2	30.74%	0.75	0.23
Italy	**3.10**	77.1	4.02%	0.70	0.03
Spain	**24.42**	33.4	73.16%	0.75	0.55
UK	**3.56**	90.8	3.92%	0.70	0.03

Source: Cedigaz

- Relying on Holz and Pavel[730] elasticity of US natural gas demand (-0.90)[731] is used with the above indices to determine the effect of changes in LNG price;

[725] As stated earlier, the ultimate aim of Uniform Pricing is keeping LNG Price(s) *higher than would have been*

[726] For instance, some terms in EU-Algeria trade agreement applies to existing contracts. Although the agreement is bilateral, other exporters could be compelled indirectly to do same. *See* EUROPA, *Commission and Algeria reach agreement on territorial restrictions and alternative clauses in gas supply contracts*.

[727] Holz, F. et' al *A Strategic Model of European Gas Supply (GASMOD)*, 2006 Discussion Papers of DIW Berlin 551, DIW Berlin, German Institute for Economic Research.

[728] Each Country's index is increased/decreased by 0.05 (against the regional index: -0.7) depending on the share of natural gas in the importer's energy mix (i.e. +0.05 for relatively low gas consuming countries and vice versa). In this Scenario, the natural gas elasticity indices are further adjusted, by the percentage of LNG supplied to each market, to determine the corresponding effect of a change in LNG price (Table 4.2 shows the elasticity indices).

- In addition to the above, all prior **Base Case** assumptions still hold

4.3.1.2 Simulation Outcome[732]

A simulation of 1000 iterations reveals, with about 95% probability, an increase in the revenue of exporting countries. Appendix 1 captures the probability distribution and significance of the outcomes. The output graphs show a good distribution spread for the results obtained and this indicates a significant range relative to the likelihood of occurrence.

Given a high probability of obtaining desirable results, a small spread in possible outcomes is generally preferable. In addition, the graphs show that the probability of the occurrence is fairly concentrated around specific outcomes rather than being uniform across the range. It is evident from the graphs, however, that the change in monthly revenue of all exporters, yield a better spread than the change in unit price. This is rational because of the diverse range of prices at which LNG is sold in different markets.

Table 4.3 Model Result: Change in Exporters' revenues and market shares due to Uniform Formula induced price rise

			% CHANGE IN EXPORT PRICE DUE TO U.P				
EXPORTERS	***% Δ IN REVENUE***	***% Δ IN MARKET SHARE***	**FRANCE**	**ITALY**	**SPAIN**	**UK**	**U.S.A**
ALGERIA	*8.48*	-1.43%	48.62%	57.96%	57.96%	0.00%	37.79%
EGYPT	*-16.16%*	-1.66%	44.81%	11.88%	11.88%	0.00	0.00
LIBYA	*-23.89%*	-0.31%	0.00	0.00	68.67%	0.00	0.00
NIGERIA	*-2.17%*	-0.45%	44.81%	54.27%	54.27%	0.00	3.69%
QATAR	*37.91%*	4.37%	0.00	65.94%	65.94%	40.94%	56.21%
TRINIDAD	*2.92%*	-0.51%	0.00	0.00	50.00%	0.00	24.85%

In the inelastic demand scenario,[733] all the exporters recorded positive price gains due to the application of the uniform formula. Accordingly, Table 4.3 shows (in

[729] BP Statistical Review of World Energy 2007

[730] Holz, F. and Pavel, F., *Will there be enough for everybody? at* www.infraday.tu-berlin.de/fileadmin/documents/infraday/2005/papers/pavel_holz_Will_There_be_Enough_for_Everybody.pdf

[731] Unlike Holz and Pavel, the elasticity is adjusted by 0.1 in absolute value to account for the decreasing North American production and increasing share of gas in the US energy mix.

columns 4 to 8) the percentage change in unit price, for the respective exporters in different markets. In this regard, Qatar benefits comparatively more, while Trinidad gains the least - this is traceable to the fact that Trinidad and Tobago exports its LNG mainly to the US.

Moreover, Table 4.3 also captures (in column 2) the percentage change in exporters' Monthly Revenue in the elastic demand scenario. This is different from the inelastic demand scenario – as reflected in Appendix 1. The reason is because, when demand becomes elastic,[734] it results in a reduction in imports (market shares – Column 3) and revenues for some exporters. From this static perspective, it is notable from the Table that Egypt, Libya and Nigeria suffer revenue losses. Algeria, Qatar and Trinidad, on the other hand, earned more revenue. Similar to the price gain situation, Qatar gained the most revenue absolutely and relatively, while Trinidad gained the least. From an importer's perspective, Spain could incur the highest price increase because it relies heavily on contracted LNG and has a rigid domestic gas market.[735]

The change in revenue is due to a simultaneous (iterated) price adjustment in comparison with the base case. It generates the possibility of swapping or interchanging supply/destination locations for certain suppliers - but only to the extent of liquefaction capacity available. Given that piped gas supply is a competitor for LNG, there is possibility of diversion of gas to pipeline export for the losing exporters.[736]

From the exercise, it has been found that there is clearly a change in market share for all exporters but the exact level of change depends not only on the elasticity of demand in each importing market, but also on the demand situations in various other importing markets and how importers respond in general. Exporters' response

[732] See Simulation Summary; @Risk Summary Reports and Output Graphs, in Appendix 1, as guide to understanding this sub-section.
[733] When importers do not respond to UP- induced changes in price.
[734] Indicating a medium/long run reduction in demand due to the sudden adoption of the Uniform Pricing Formula
[735] Historically, Spain takes all its contracted LNG volumes and sometimes resells.
[736] Perhaps, Algeria that has significant pipeline export capacity (to do this) could utilize the opportunity to compensate those that lost revenue. More so because the choice of swapping is open to all exporters within the group.

to the change in market share and revenue would, furthermore, depend on their uncontracted liquefaction capacity and the spot market price for LNG. Ultimately, in a dynamic scenario, Uniform Price can only impact on exporters' revenue negatively, overtime, if the consequent fall in demand[737] surpasses the exogenously generated price increase.

4.3.1.3 Theoretical Explanation of Outcome

Economic theories of elasticity, demand and supply confirm the above simulation results. The exercise indicates that: Each exporter's revenue increases by (**ΔP**) * (**Q_e**) and the Group's revenue also increases by $\sum_{e=1}^{6}(\Delta \mathbf{P}) * (Q_e)$.

Where: **$\Delta P = UP - P_t$** (i.e. Change in Unit Price)

UP is the Uniform Price determined through the new Formula

P_t is the Contracted Price

Q_e is the Average Monthly Contract Volume for Exporter 'e'

In the short term, to the extent that gas is less costly;[738] appliance (capital) stock is fixed; storage capacity is constant; and LNG importers are willing to pay the new price (UP). Given the short-run assumption of inelasticity, each Exporter's market share should not change.

Theoretically, the long run outcome is obtainable only to the extent that there would be sufficient affordable substitutes to replace LNG in each domestic market.[739] The result simply indicates that, 90% of the time, each exporter's volume is reduced by the value ΔQ_e[740], while that of the Group is reduced by $\sum_{e=1}^{6}(\Delta Q_e)$ ceteris paribus.

Where:

ΔQ_e = $\sum_{i=1}^{5}(\Delta Q_{ei})$ (i.e. the total change in Average Monthly Contract Volumes from Exporter (e) to all importers (i = 1,2,3…5))

$\Delta Q_{ei} = (Q_{ei} * \psi_i)$

[737] This has to occur, generally, in the importing markets.
[738] Relative to substitute fuels and the cost of Carbon Emission Permits
[739] *In the long run we're all dead"* Keynes, J.M. quoted in http://www.brainyquote.com/quotes/quotes/j/johnmaynar110030.html
[740] Change in Average Monthly Contracted Volume for exporter (e).

ΔQ_{ei} is change in Average Monthly Contract Volume from Exporter (e) to importer (i)

Q_{ei} is Average Monthly Contract Volume from Exporter (e) to importer (i)

ψ_i is the price elasticity of demand for LNG in importing-Country (**i**)

To the extent that relative gains, from the new price are fair, cheating may not be attractive. This is economically rational because higher gas prices could motivate Exporters to collude and reap the margin,[741] rather than let importing countries have it. Despite the above economic (price and revenue) incentives indicated by the model, the following conditions would enhance the feasibility of uniform pricing, as a market influence mechanism:

- **Transparent LNG Pricing[742]**

A neutral pricing mechanism that is transparent, independent of any specific project and not directly linked to any domestic/regional gas market. This would ensure that the Uniform Price does not alter the basis risk inherent in most established grids. This is because the flow of LNG into liquid natural gas markets adjusts the basis differentials[743]. For illustration, assume the Uniform Formula is based on Henry Hub natural gas price. An LNG vessel imported into the US east coast, for instance, would automatically adjust the basis differentials, Henry Hub gas price and simultaneously the Uniform LNG Price.

The proposed uniform pricing formula (or any other) can not be a mechanism for standardizing LNG pricing and simultaneously be a mechanism for influencing[744] the market. It would be completely ineffective for Exporters to influence the various pricing mechanisms in the Atlantic Basin with one and the same Pricing Formula. Differences in pricing patterns across the importing markets would make Uniform

[741] Gas has two price components: Production cost component borne by producers and substitution cost by the consumers.

[742] No global reference price for LNG exists and so the current pricing regime is not open but negotiated secretly and shrouded in mutual suspicion. Essentially, it should be one that is linked indirectly to importing markets but not linked directly to competing fuels (coal, electricity, nuclear, solar or biofuels). More specifically, an LNG Hub determined price (either Dubai's LNG Hub (DUB) or Qatar's International Mercantile Exchange or any other) may suffice.

[743] On a pipeline network, this can be defined generally as the geographic pricing relationships among different points.

[744] Determining a higher market price for LNG

Pricing ineffective as there would be various loopholes and price incentives for exporters to cheat. A more transparent and standard LNG pricing regime or benchmark is a necessary condition[745] for the cooperative sharing of trade information by exporters and collusive market determination.

- **Formula should be simple**:

Given a transparent pricing regime, the Uniform Formula should be simple enough to make profit sharing either unnecessary or straight-forward. This is because it would enable exporters to determine the absolute/relative benefits of collusion and therefore, make trade-offs if and when necessary. There would, also be no need for large-scale cheating among exporters if the PSM element of the Formula (**μ**) is standardised. The vital questions demanding answers are: By what mechanism would 'r' be set? What level of 'r' (and '1-r') would, simultaneously, satisfy exporters and also be an incentive for importers to divert cargoes to high price markets.

- **Inelasticity of LNG Demand and Low Storage Capacity:**

The availability of higher-priced substitute-fuels increases dependence on LNG when natural gas storage capacity is low. Conversely, low-priced alternative fuels could hamper LNG imports (and UP) even if gas storage is low in that market.

The above conditions define some scenarios in which uniform pricing could be feasible? The next subsection simulates the Volume Control Mechanism.

4.3.2 Volume Control

A supply-restricting scenario is captured here in the model. This work presumes that export volumes could be controlled by cutting LNG production based on each Exporter's existing Sales Contracts (and uncontracted volumes).[746] Production levels are, therefore, curtailed by equal percentage to ensure that each country's contracted volume is constrained. So, the demand elasticity index in each importing market and the reduction in production are used to determine specific increase in LNG price. One thousand iterations are then run on varying export quotas (from 1%

[745] There are divergent opinions that a traded LNG contract with transparent price would be a challenge to exporters. This author, however, disagrees with the argument because traded LNG contracts permit speculative and secondary trading activities.

[746] Depending on the prevailing (target) price; conditions in LNG (other energy) markets and oil price, quotas are subsequently adjusted or reallocated, as more liquefaction capacity is added.

to 5%) to determine the outcomes[747] in relation to Price, Revenue and Market Share.

This conception of VC is adopted for clarity and ease of application in the model. The approach is also based on the industry practice that allows part of the contracted capacity to vary. As is the practice in real life, a fixed part (usually between 1 and 10%) of the contracted liquefaction capacity may be varied at the discretion of the exporting country. Exporters now include clauses that enable such optional volumes and flexible diversion in the sales contracts.[748] Besides, increasing proportion of liquefaction capacity across the globe is uncontracted or self-contracted. For instance, in 2005, only 188.81Bcm of the 243Bcm global liquefaction capacity was traded. Table 4.4 shows the 2006 figures and the 2015 projections for each exporting country.

Table 4.4 Exporters' uncontracted liquefaction capacity[749]

EXPORTERS	2006 LIQUEFACTION CAPACITY(mtpa)	*UNCONTRACTED CAPACITY* (%)	2015 LIQUEFACTION CAPACITY (mtpa)	*UNCONTRACTED CAPACITY* (%)
ALGERIA	21.95	4.10	25.95	69.63
EGYPT	12.20	14.75	20.80	39.18
LIBYA	2.30	52.17	N/A	N/A
NIGERIA	17.05	11.44	73.95	66.26
QATAR	25.50	12.86	77.00	ALL
TRINIDAD	15.40	37.34	20.60	53.16

Source: Petroleum Economist

4.3.2.1 Scenario Specific Assumptions/Inputs

- Exporters' Revenue Function ($\sum_{e=1}^{5}\sum_{i=1}^{6}(P_{ei})(Q_{ei})$) is still the primary function

- Previous elasticity (ψ_i) assumptions still hold but they are not adjusted by the percentage of LNG supplied to each market, to determine the corresponding effect of a change in LNG price[750]

[747] Only simulation outcomes for the 1% reduction in exports are reported here.
[748] The Australian North West Shelf (NWS) project's contracts were recently renewed along this line.
[749] Extracted by author from Petroleum Economist Limited, *The Future of LNG*, (2007 Edition), based on LNG trade movements through future contracts in place by end 2006.

- No sudden change in average seasonal storage level
- Increase in domestic or alternative natural gas supply insignificant or unavailable[751]
- Constrained LNG supply is equivalent to sudden decrease in natural gas supply due to excess demand for LNG[752] and vice versa. Therefore, a positive change in demand[753] (δ) would generate a price increase (ΔP) equal to the quotient $\left(\frac{\delta}{\Psi_i}\right)$
- Hence, $\left(\Delta P = \frac{\delta}{\Psi_i}\right)$ is the desired increase in Price expected from an LNG supply gap ((δ) measured in terms of available[754] natural gas supply)
- All existing contract volumes are reduced by **δ**%
- Maximum exportable quota for each Country is (1- **δ)**%
- LNG is the marginal supply to the importing markets: therefore balances any difference between demand and supply at time t;

4.3.2.2 Simulation Outcome[755]

The simulation reveals, with over 90% chance, increase in the price of LNG[756] payable by the importers to exporting countries. Similar to the UP case, the output distributions are spread across a small range relative to their probabilities. The graphs also indicate that the probability distributions are fairly concentrated rather than uniform. Figure 4.5 captures the percentage change in Natural Gas price due to 1% reduction in LNG exports from each of the six exporting countries, given the price elasticity assumptions,[757] from a static perspective.

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[750] It is assumed that any reduction in LNG Exports automatically reduces natural gas supply by the volume. The natural gas elasticity indices are, therefore, used directly to determine the corresponding effect of a change in LNG supply (see formula for ΔP above).

[751] Such an assumption could overstate the effects of LNG supply restriction but, in a 2013 scenario, it is valid given the long lead (response) time of natural gas (or pipeline) projects. Furthermore, most of the consuming countries (including the US and UK) may not have sufficient gas deposits.

[752] This is because natural gas prices in most competitive markets respond to demand increases.

[753] Conversely, an equivalent decrease in Supply.

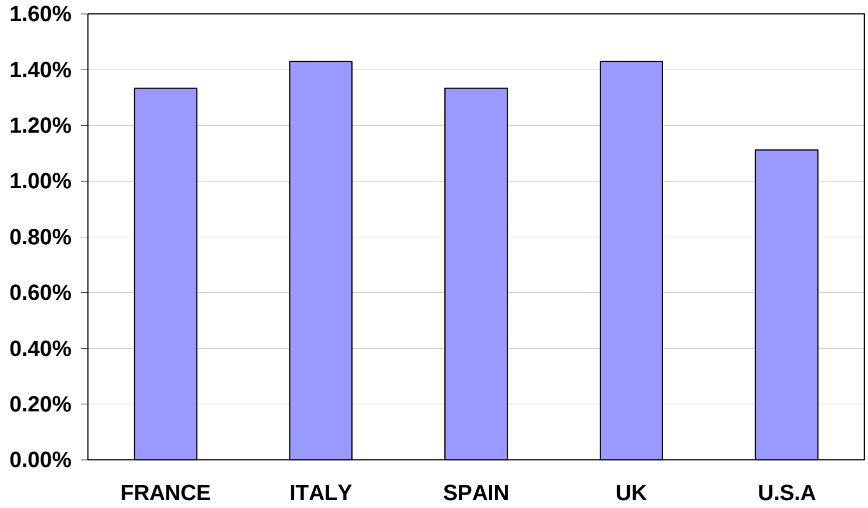
[754] This includes both domestic production and pipeline supply.

[755] See Simulation Summary; @Risk Summary Reports and Output Graphs, in the Appendix 2, as guide to understanding of this sub-section.

[756] Supply reduction raise natural gas price in the importing market and this consequently increases the netback for LNG from that Market.

Initially, there is no change in market share due to the equal reduction in export volume. Subsequently, if demand does not fall, then the volume of spot LNG and/or pipeline gas export could increase.[758] The graph indicates that, given the assumptions, the US is the least affected by the constrained LNG supply problem simulated, while, Italy is be the worst affected after Spain.[759]

Figure 4.5 Percentage Change in Natural Gas Price due to 1% reduction in LNG exports from each of the 6 exporting countries



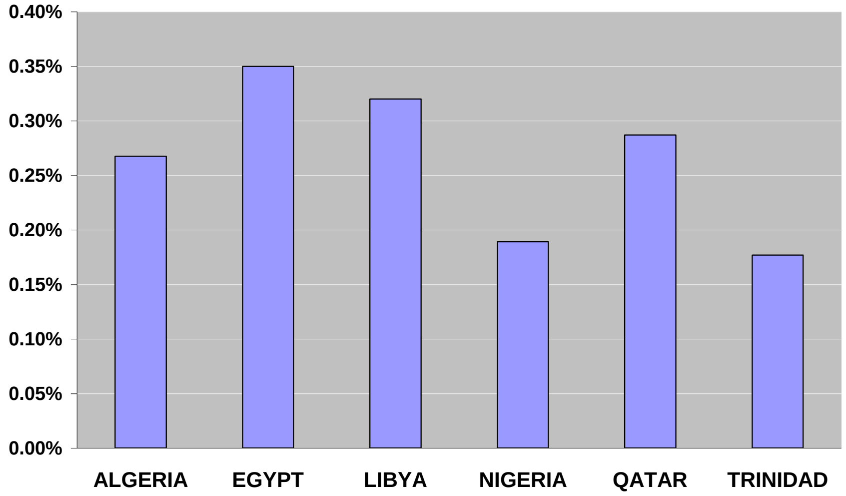
In the short-run, to the extent that demand does not change, each exporter's revenue increases proportionately by the price rise. The above result is similar to that obtained by the EMF's Study in their constrained LNG scenario. In their cases, however, constrains were placed on regasification terminals (capacity) while European importers were grouped together. Their result[760] did not capture the size of each exporter's restriction nor was the volume of import restriction in individual importing markets.

A probable demand-side response to this scenario is captured, from a long run perspective, through the assumed elasticity indices. Because the price increase is

[757] Indicating demand-side response to the sudden uniform price change
[758] Likely changes in spot LNG (or pipeline gas) supply is not simulated here but it is very relevant if demand remains constant/increases. What is more significant, however, is that most of the exporting countries considered here participate in spot LNG trade.
[759] This could be due to the poor liquidity in these markets and the lack of pipeline connection to other European markets. These markets are extensively described in Chapter 2 and the results contextualized in Chapter 5.
[760] See Figures 4.1 and 4.2, as well as, subsection 4.1.2 (Literature Review).

more than the demand elasticity, generally, all exporters recorded positive change in revenue. Figure 4.6 above shows the corresponding percentage increase, in average monthly revenue, for respective exporters due to the reduction in LNG exports.[761] Specifically, Egypt gains more, while Trinidad gains the least relatively.

Figure 4.6 Percentage Change in Monthly Revenue for the exporting countries due to 1% reduction in LNG exports



The model would not yield a similar result if quotas are not applied equally among exporters. If different quotas are to be considered, then the allocation has to be effective and specific enough[762] such that each exporter gains sufficiently[763] from the decrease in export. In such a scenario, though not simulated here, some exporters could loose/gain market share in the long term supply market. But, as importers respond to the supply-side shock, demand (and price) for spot LNG imports could increase as well - to the benefit of exporters (ultimately).

4.3.2.3 Theoretical Explanation of Outcome

The simulation process - a thousand iterations – indicates individual and collective increase in the revenue of exporting countries. Specifically, each exporter's price changes and revenue increases by (**ΔP * Q_e**).

[761] The probability distributions for these outcomes - indicating their spread and significance - could be seen in Appendix 2 ((a) to (e)).
[762] Because different pricing formulas are used for selling to different markets both transparently and secretly.
[763] Price increase should be high enough to generate higher revenue despite the reduction in export.

The Group's revenue also increases by $\sum_{e=1}^{6}(\Delta \mathbf{P}) * (Q_e)$

Where: **ΔP = P_t (1+%ΔP) (**i.e. Change in Unit Price**);**

%ΔP is the percentage change in price due to **δ%** change in AMCV

P_t is the Contracted Price; **Q_e** is the new **AMCV** due to **δ**

Theoretically, a sustained LNG supply restriction would shift the long run natural gas price path upward, ceteris paribus. To the extent that the sudden shift in price path (upward) becomes permanent in the importing markets, LNG supply manipulation would affect price. Economic theory, therefore, supports the results, if the assumption that $\left(\Delta P = \frac{\delta}{\Psi_i}\right)$ is true; and to the extent that gas is a less costly[764] fuel; appliance (capital) stock is fixed; storage capacity is constant; and end-users are indifferent to the new price but concerned about supply security. In the alternative, however, the higher long-run price path could be a motivation for fringe producers to produce/invest more; better fuel-efficiency and consequently change in supply/demand.

It is sometimes argued that LNG imports are small[765] and that it is a price taker. But, since prices are marginally determined,[766] imports (or restrained imports) generate disproportionate impacts on domestic natural gas prices.[767] This implies that constrained LNG exports can either result in higher netback value or spot price for LNG and in both cases exporters benefit. So, Volume Control would be feasible in the following scenarios:

- **Accurate Elasticity Indices:**

The elasticity estimates[768] for each market ought to be accurate enough to determine the long-term price. There seems to be no literature on the price elasticity of LNG demand. This could be traceable to the fact that LNG has been a price taker. A second reason is because it does not have a unique reference price.

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[764] Vis-à-vis substitute fuels and the cost of Carbon Emission Permits

[765] Relative to the volume of gas consumed in the major Atlantic importing markets (hence a price taker).

[766] According to economic theory, the long run price of natural gas, in any market, is determined by the interaction or intersection of the marginal supply source (curve) with demand (in that market and others).

[767] As well as, imported LNG price both in the short term (Spot market) and in the long run.

[768] The long-run, own price elasticities for natural gas for OECD Importers could lie between –0.774 and 0.075 according to Liu, G., in *Estimating Energy Demand Elasticities for OECD Countries*. Discussion Papers Statistics, Norway, 2004.

■ **A sort of scarcity** (real or imaginary)

Exporters would need some tightness to effectively manipulate the market or determine price. This means that for prices in the Atlantic Basin to be affected by constrained exports consumers must perceive the supply reduction as an impending scarcity.[769] The perceived scarcity should be sufficient to either increase domestic pipeline gas prices or spot LNG price and consequently LNG netbacks.[770] In other words, LNG ought to be the marginal source of natural gas supply in the importing market. If otherwise, exporters would have to ensure that the volume of LNG withheld from each market is significant relative to the size of the importing market. The next vital question is: to what extent could the price (or revenue) increase compensate for the associated costs of constraining exports?

■ **Cost of holding capacity must be low relative to price gains**:

The economic question of compensation for spare capacity is, theoretically and practically, fundamental to the feasibility of any volume control mechanism. Theoretically, the cost of keeping liquefaction capacity idle is a disincentive to supply restriction. However, higher netbacks (or spot prices) could be an incentive to withhold some volumes for better yielding long/short term transactions.

The comparison of spare capacity cost against expected benefits was not considered in the model for simplicity and clarity. Nevertheless, the net benefit of holding spare capacity could be determined by matching the foregone revenue[771] against the expected revenue (from the new price and volume). Another realistic but more complex[772] approach, arguably, is to compare the net present value of all future expected revenue with the foregone revenue. There are also unquantifiable costs of restricting exports.

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[769] Either in the importing market, other importing markets or LNG market

[770] An underlying presumption to this assertion is that is that natural gas stock is either too low or there is insufficient storage capacity.

[771] That is the product of 'current netback' and 'withheld capacity'.

[772] The expected netback value, from different price forecasts for each importing market, would be determined for each exporter.

In practice, however, liquefaction plants rarely run up to their nameplate capacity.[773] So, a key consideration, for exporters would be to meet project finance repayment obligation. Moreover, if market share and cartel profit is to depend on such a nebulous concept as 'capacity' there may be more incentive to try to find ways to increase it by debottlenecking - real or imagined. Therefore, VC makes economic sense, only to the extent that the margin from such high-yield transactions exceeds the opportunity costs of holding spare capacity after fulfilling project finance obligations (if any).

- **Management of risks with financial instruments:**

The above discourse highlights the costs of contracting LNG on the basis of projected prices (formulas) in today's trading environment. Therefore, contracts would have to be very flexible with respect to price, volume and destination for VC to be feasible. This would require LNG project financiers to use financial instruments to manage their risks as the market evolves.

- **Low Transport Cost or LNG Trading Hub/Exchange:**

It is highly probable that importers would resort to spot cargoes to replace restricted LNG exports. As the number of spot deals increases, it would be easier for exporters to restrain LNG volumes - as a means of influencing price (and the market). The emergence of a liquid trading hub, therefore, would easily facilitate VC in both Contract and Spot markets for LNG. For instance, VC could impact Spot LNG just as OPEC actions affect oil price through speculators in the oil market.

Given the proportion of transport cost in LNG Price, a low shipping cost regime would also enhance the prospects of VC. The reason being that negotiable rent is reduced when the transport cost per unit of LNG over a nautical mile is high. This is especially so if the transactions are destination ex-ship (d.e.s). Moreover, reduction in LNG transport costs increases the probability of finding short-term/spot trading partners.[774]

[773] Cyclical or seasonal shocks create idle capacity sometimes even though productive capacity (for revenue/profit) is the aim of project financiers and investors.
[774] Brito, D.L. and Hartley P.R., *Expectations and the evolving World Gas Market*; last paragraph, p.23, The Energy Journal, Vol. 28, No. 1, 2007.

4.3.3 Uniform Pricing (UP) or Volume Control (VC)

Exogenous price determination may be possible if exporting countries exploit the substitution cost of end users rather than competing to be the least cost producer. The best means of achieving the latter is also an important issue. In certain conditions, it appears easier to influence price by a Uniform Pricing Formula while in others Volume Control is easier. Accordingly, an attempt is made to compare both mechanisms in the following paragraphs - giving further insight into their feasibility.

Provided LNG is the only marginal source of supply in most markets, export restrictions would affect the price of both pipeline gas and LNG. Exporters only need to ensure that a significant[775] volume is restricted globally. Therefore, with respect to the various pricing patterns used in the Atlantic, the Volume Control mechanism would be easier to apply. Large volumes of withheld LNG, however, imply lower exports with its revenue and contractual implications for exporters. Some exporters may then resort to cheating which is very difficult to detect or penalise. In this context, UP seems a less challenging option. Either of the mechanisms, however, can arguably be adopted without breaching contracts and the outcome is still valid even if spot transactions become predominant.[776]

It is remarkable that the UP and VC scenarios yielded different results[777] although the same elasticity indices were applied. Because it is not a theoretical expectation, there has to be a practical explanation of this outcome - both mechanisms do have different transmission paths. Specifically, VCM is a means[778] to an end, while UPM is an end in itself – higher LNG price generated from the new formula.[779] Besides, LNG doubles as marginal gas supply in some markets[780] and main gas supply in others. As a result of the above reasons, the effect of a change in pricing formula (principle) is not symmetrical to a decrease in contracted capacity.

[775] With respect to opportunity costs and the proportion of LNG in each gas market.
[776] Percentage of LNG traded globally on Spot basis has grown rapidly (but seasonally in the US and UK) from 1% in 1996, 8% in 2002, 11.6% in 2004 to about 17% in 2006.
[777] In terms of, change in market share and revenue.
[778] VC is an outright exogenous supply-side shock but its effect could be suppressed by other determinants of natural gas price in an importing market.
[779] Albeit the Formula has to be adopted in long term LNG contracts - imposed or negotiated.

4.4 CONCLUSION

The question of feasibility has been modelled in a simple and clear manner. Considering all the issues relating to the research together would have been very complicated. Given demand, to some extent, Uniform Pricing or Volume control is statistically feasible and Exporters could influence trade. But, the exercise reveals that a demand-led market[781] is a necessary condition for either mechanism to be feasible.

Despite the above conclusion, the scenarios conducive for either mechanism do raise pertinent practical issues for consideration. It is necessary to know the extent to which the above conditions, for the feasibility of UP/VC, are realistic and/or sustainable. Given the effect of gas storage infrastructure on a country's LNG (natural gas) demand, for instance, the outcome of the simulation exercise could differ if storage capacity is allowed to vary. Second, if such scenarios are attainable and either mechanism is feasible, what could be the effects on trade? The next Chapter considers these and other questions.

[780] In such markets, LNG is a price taker.
[781] Even if, it occurs seasonally, provided it empowers exporters.

CHAPTER FIVE

CONTEXTUAL APPLICATION OF SIMULATION RESULTS

5.1.1 Introduction

The simulation exercise, in Chapter Four, generated possible outcomes of uniform pricing and volume control mechanisms. The chapter also compared both scenarios and emphasized the need for a profit splitting formula with which cartel-gains could be allocated. It is necessary to evaluate the results within the context of each exporting country. This chapter is an attempt to answer the following sub-questions:

- What conceivable permutations of uniform pricing (UP) and/or volume control (VC) are realistic?
- What are the key considerations for adopting uniform pricing or volume control?
- What are the implications[782] of uniform pricing or volume control for each exporter?

The chapter is divided into four sections. It begins with a review of some literature on cartel formation. As a foundation for the analytical framework, the literature review captures the reasoning behind cartels;[783] conditions for being effective and the principles that underlie the kind of volume/price "games" they play. Based on the criteria defined in section 5.1.2, section 5.2 analyzes the simulation results for both scenarios from each exporter's perspective. In addition to the criteria, the exposition also draws from the peculiar circumstances of each country as described in Chapters Two and Three to reveal the basic motivations or considerations for parties involved in the cartel game.

5.1.2 Analytical Framework

Given that uniform pricing and volume control are potential instruments of market determination, inferences shall be drawn from existing cartel literature to establish the analytical framework. Generally, a cartel may be defined as "a combination of producers or sellers that join together to control a product's production or price."[784]

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[782] Attempt is also made, in the chapter, to show the conceivable benefits or losses to exporters from uniform pricing or volume control.
[783] That is the factors that motivate current and prospective cartel members.
[784] Garner, B. A, (Ed.); Black's Law Dictionary, 7th edition (Minnesota: West Group, 1999)

Therefore, various producers or sellers in the form of private firms or governments or a mixture of both may form a cartel.[785] From the economic literature, four characteristics of a cartel can be deduced. A cartel influences the market by:

- Having a small number of sellers/producers with a significant share of the market;
- Deterring entry of new producers at the fringe by various means;
- Controlling available capacity (supply) and capacity expansion by assigning quotas to its members;
- Taking steps (enforcing quotas) with the principal aim of **controlling price**; maximizing revenue; maintaining and/or increasing market share.[786]

Table 5.1 Some successful international natural resource cartels[787]

Commodity	Quota	Minimum Price	Action to defend Prices	Maximum Market Share (%)	Price Increase
Diamond	Yes	Yes	Yes	90.0	10 Fold
Coffee	Yes	Yes	Yes	95.0	6 Fold
Bauxite	Yes	Yes	Yes	81.0	2 Fold
Tin	Yes	Yes	Yes	86.0	2.5 Fold
Rubber	Yes	Yes	Yes	80.0	5 Fold

Markets for various internationally traded commodities[788] have been cartelized at different times. Some were unsuccessful while others (uranium, bauxite and diamond) have enjoyed varying degrees of success.[789] In a historical study by Eckbo[790], the efforts of such cartels were reviewed and only nineteen, out of the fifty-one cartels investigated, were successful.[791] Huettner and Alhajji[792] also compared few of these cartels with OPEC and the extent of their success is shown in table 5.1.

[785] Desta, M. G., *OPEC, the WTO, Regionalism and Unilateralism*, in 3 Journal of World Trade, Vol. 37, (2003)
[786] Alhajji A.F. and Huettner D. *OPEC and other Commodity cartels: a comparison.* Page 1153, Paragraph 5, 28 Energy Policy, (2000)
[787] Table and its content were extracted from Alhajji, A. and Huettner, D., *OPEC and other commodity cartels: a comparison*, in Vol. 28, Energy Policy, 2000.
[788] At one time or the other, in the history of global commerce, ranging from coffee, metals to minerals.
[789] Besanko, D; et'al; Economics of Strategy, 3rd Ed; Last Paragraph, Example 6.4, Page 213, (New York: John Wiley & Sons, 2004).
[790] Eckbo, P., *OPEC and the Experience of some non-petroleum international cartels,* MIT Energy Lab working paper, June 1975 as quoted in Pindyck, R., *The cartelization of world commodity markets*, in Vol. 69, No. 2, The American Economic Review, May 1979.
[791] They succeeded in making price higher than it would have been – the main objective of UP and VC here.

Drawing from Eckbo's effort, Pindyck evaluated the reasons behind cartel successes. According to Pindyck, there are two preconditions for a successful cartel. One of the conditions put forward by Pindyck is "the potential for monopoly profit". He asserts that this issue is fundamental and becomes very serious if cartel prices do not differ significantly from competitive prices. Within this context, the outcome of Chapter Four apparently shows the potential for cartel profit in LNG trade.[793]

A second issue, highlighted by Pindyck, relates to the basic organisational and stability problems of cartels. That is, an accord on price and production levels,[794] as well as, a means of sharing the profits, while deterring cheats.[795] This set of conditions is similar to initial studies by Mikdashi[796] and Bergsten.[797] While it may seem that the tendency for monopoly profit is sufficient to alleviate the organisation problems,[798] this may not be the case for LNG.

One reason is because LNG is still being traded regionally and lacks a transparent pricing regime. Furthermore, like Fog had argued, determination of price and quantity is complicated by the existence of substitutes[799] in the importing markets; different constraints[800] faced by producers; and their perspectives of demand relative to existing supply.[801]

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[792] Alhajji, A. and Huettner, D., *OPEC and other commodity cartels: a comparison*, in Vol. 28, Energy Policy, 2000.
[793] One may even argue that some of such monopoly profit is already being earned by LNG exporters in the spot market. The next chapter explicitly describes the current market situation.
[794] Pindyck, R., *The cartelization of world commodity markets.* Vol. 69, No. 2, The American Economic Review, May 1979.
[795] The need to detect and/or deter cheating, however, would depend on the Cartel's modus operandi and the nature of the industry.
[796] Mikdashi, Z. *Collusion could work*, No. 14, Foreign Policy, spring, 1974.
[797] Bergsten, C., *The threat is real*, No. 14, Foreign Policy, spring, 1974.
[798] Like Pindyck assumed and suggested that the costs of maintaining a cartel would be more tolerable when the expected monopoly rent is high.
[799] Substitutes affect the elasticity of demand. The existence of substitutes is an important consideration for each LNG importer due to the peculiarity of each importing country. It fundamentally affects each exporter's perception of the market and potential cartel/monopoly gains. This is one of the reasons for the application of different elasticity indices in Chapter 4.
[800] This may differ across producers from reserve levels to domestic demand and revenue needs.
[801] Fog, B., *How are Cartel prices determined?* Vol. 5, Journal of Industrial Economics, November 1976.

In an exercise to show the inadequacy of cartel theory to explain OPEC behaviour, Alhajji and Huettner[802] derived six cartel features from the economic literature. Namely, quota system; monitoring system; punishment mechanism; side payments or buffer stocks and large market share.[803] In concluding, they opined that the dominant producer role is another factor that significantly contributes to the success of a producers' group in raising price. Given the similarities of oil and LNG this is a factor worth considering extensively – is a swing producer essential for the success of uniform pricing or volume control?

Comprehensively analyzing the benefits of a supply-side action would be very complex within the context of an evolving LNG industry. Therefore, it is necessary to evaluate the simulation results[804] so as to determine the costs, to each exporting country, of raising and maintaining a higher cartel price for LNG. Agreeing more with Alhajji, Heuttner and Fog than Pindyck and Hnyilicza,[805] the following criteria would facilitate such a country-specific discourse:

- **In terms of revenue, market share and price differential**, is each country better-off or worse-off given its:
    - Existing and potential liquefaction capacity
    - Dependence on export revenue or discount rate[806]
    - Current and forecasted energy (gas) demand levels

Demand considerations (domestic and external) are pivotal to each country's exportable volume, as well as, the strategy of a dominant player (discussed in sections 5.1.2.3 and 5.3). This is an important issue, although often ignored. For instance, Osborne[807] proposed that retaliation, by other cartel members, whenever

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[802] Alhajji, A. and Huettner, D., *OPEC and other commodity cartels: a comparison,* in Vol. 28, Energy Policy, 2000.
[803] These characteristics are similar to those in Pindyck, R., *The cartelization of world commodity markets.* Vol. 69, No. 2, The American Economic Review, May 1979.
[804] See summarised result in Table 5.3 and Figure 5.2 on pages 215 and 230 respectively.
[805] Hnyilicza, E., and Pindyck, R., *Pricing policies for a Two-Part Exhaustible Resource Cartel: The Case of OPEC,* Volume 8, European Economic Review, August, 1976. In their model of OPEC, these issues were considered as "simple differences in objectives" that are easily reconcilable. For LNG they could be more challenging. In a later article, however, Pindyck suggested, and rightly so, that resource "depletion problems may critically affect intertemporal pricing and production decisions".
[806] Discount rate, here, defines a country's willingness to forego present gains for higher prices in the future.
[807] Osborne, D., *Cartel Problems*, in Vol. 66, No. 5, The American Economic Review, December, 1976.

one member cheats would deter cheating. Contesting Osborne's resolution of cartel problems, Mills and Elzinga opined that arbitrage opportunities distort cartel members' perception of the market, leading to multiple "joint profit-maximizing points".[808]

Besides, Osborne did not consider supply lead times relative to demand levels, as well as, the exhaustible nature of minerals. Demand levels significantly affect exporters' perception of the market and also their ability to agree on a cartel price and volume. Moreover, retaliation - which Osborne proposed – is a function of existing and/or potential demand.

5.1.2.1 Resource abundance

This includes proven reserves of petroleum resources which a country has. Generally, the larger the existing gas reserves, the more interested an exporting country would be in a cartel. Specifically, a country that currently exports LNG and has large gas reserves would make less profit in a competitive supply situation than when the market is cartelized. In other words, higher reserves enhance the potential cartel rent relative to potential profits[809] without collusion. It is, therefore, arguable that a gas-rich LNG exporting country (like Algeria or Russia) would be keener about influencing the market than a country with little reserves. Conversely, a relatively new LNG exporter with small reserves would be either cautious or indifferent about a cartel.

This is because there are two issues inherent in the benefits, derivable by fringe producers, from cartel pricing. Those with low reserve status may be interested in maximizing their short-term gains and therefore encourage oversupply – with the consequent pressure on cartel rent. But, those with large gas reserves (like Venezuela) could also loose in the long run if they act likewise or indifferently.[810] Within this context, it would be important for a prospective LNG cartel to consider the possible reaction from other gas producers. This issue would not be covered

[808] Mills, D. and Elzinga, K., *Cartel Problems: Comment*, in Vol. 68 No. 5, The American Economic Review, December, 1978
[809] In the long run, competitive prices become lower and consequently discounted normal profits.

here but it is an area that deserves further research. Nevertheless, the probable effects[811] of uniform pricing or volume control are considered alongside other market trends in Chapter Six.

Table 5.2 Petroleum Resource Rating[812]

	High Oil	**Low Oil**
High Gas	Nigeria	Qatar
Low Gas	Libya	Algeria; Egypt; Trinidad & Tobago

A broad categorisation of resource abundance, applicable in this book is shown in Table 5.2 above. The high oil-high gas countries are assumed to have an opportunistic attitude while low oil-low gas exporters are cautious in their approach.

5.1.2.2 Diversified pricing *versus* uniform pricing

In order to, protect revenues, LNG exporters seek diverse sales portfolio with different price regimes and markets.[813] Each exporting country needs to reconcile its diverse pricing (or sales portfolio) with uniform pricing (volume control). In other words, why should an exporting country that applies diverse pricing principles to optimize its LNG sales and hedge against risk join others to fix price? Even with necessary enforcement[814] mechanism, such a country would only cooperate if it is certain to earn[815] significantly more from price fixing than from its current pricing regime.

5.1.2.3 Price Leader or Swing Producer

Economic literature[816] emphasizes the dominant-producer role of Saudi Arabia[817] as pivotal to the success of OPEC. Some key factors that determine the price strategy

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[810] Certainly, competition from piped natural gas and other LNG exporters could alter cartel strategy, but, the actual impact of fringe producers on potential cartel gains is dependent on how demand changes and producers' response to capitalize on demand lags.
[811] Effects on: new LNG/pipeline projects; markets outside the Atlantic Basin; other (fringe and emerging) LNG and piped gas producers; Contracts and Project Finance.
[812] This rating ignores existing production capacity and is based on the average proven reserves held by OPEC and the Gas exporting Countries Forum. Egypt and Trinidad are non-OPEC countries.
[813] Ball, J. and Roberts, P., *LNG as a new force in global energy security*. Paper presented at LNG15, 2007.
[814] Typical problem associated with price fixing.
[815] Economically (and maybe politically) in the short-run and long-run
[816] Some of the literature includes: Stevens, P., *National oil companies and international oil companies in the Middle East: Under the shadow of government and the resource nationalism cycle*, Vol. 1, No. 1, Journal of

of a cartel leader are politics (policy),[818] demographics, economy and energy demand. Fattouh;[819] Stevens; Alhajji and Huettner; as well as, Doran[820] emphasize the varying effects of these factors at different times in the history of OPEC. Subsequently, these same factors would be used to address the issue of an LNG price leader.

5.1.2.4 Extra rent earned

The collective gains, from UP or VC, may be complex to estimate, but it is easier to measure the extra rent achievable by each exporter. Given inelastic demand, the extra rent accruable to an exporter, due to a collusive action, may be derived from the following equation developed by John Nash and Antoine-Augustin Cournot[821]:

(Price - MC) / Price = HHI / ε

$$\therefore (Price - MC) = (Price) \times \left(\frac{HHI}{\in} \right)$$

Where: MC = Marginal Cost

Hirschmann-Herfindahl Index (HHI) = ΣM_s^2

M_s^2 = Square of market share (M_s)

ε = Price elasticity of demand

An exporter's extra rent (price differential to marginal costs[822]) is, therefore, directly related to the new price, HHI and inversely proportional to the price elasticity of

World energy Law and Business, 2008; Adelman, M., *The real oil problem,* in Regulation, spring 2004; Adelman, M, and Lynch, M; *Markets for Petroleum,* Encyclopedia of Energy, Volume 3, 2004; Claes, D., The Politics of Oil-Producer Cooperation, 2001; Alhajji, A. and Huettner, D., *OPEC and other commodity cartels: a comparison*, in Vol. 28, Energy Policy, 2000; Danielsen, A.L. The Evolution of OPEC, (1982); Griffin J.M. & Teece D.J (Eds), *Introduction* in OPEC Behaviour and World Oil Prices, 1982

[817] The nature of Saudi Arabia's role in OPEC has been termed variously in the literature as 'price maker', swing producer, 'punisher' of erring members, and 'fixed volume supplier'.

[818] Saudi's continued influence is hinged on its five-pillar oil policy. For more on the policy, see Naimi A., *Saudi Oil policy in a Globalised and Dynamic Market*, Presentation at the 15th World Petroleum Congress, China, 1997.

[819] Fattouh, B., *OPEC Pricing Power: The need for a new perspective*, OEF, WPM 31, March 2007. Relying on some other literature, Fattouh suggests the need for additional research to comprehensively ascertain Saudi Arabia's role. Perhaps, the outcome of such an exercise would highlight the transient nature of a cartel leader's strategy as the market evolves.

[820] Doran, C., *OPEC Structure and Cohesion: Exploring the Determinants of Cartel Policy*. Vol. 42, No. 1, The Journal of Politics, February, 1980.

[821] J. Nash, *Non-cooperative Games*, 286-295 Annals of Mathematics, Vol. 54, no. 2 (Sept. 1951).

[822] In addition to the differential rent, part of the consumer surplus also goes to the Exporter due to the collusive action and the inherent capacity constraint in most energy markets.

demand. Because price response, which determines the extra rent achievable, depends on elasticity, the simulation result would suffice.[823]

Finally, it is important to note that some of these criteria may not apply in both scenarios. Neither do they have equal weights for the six exporters considering their peculiar circumstances. For instance, the criterion '*Price Leader'* is more applicable to Algeria, Nigeria and Qatar than to the others. An R-factor analysis can be undertaken to allocate weights to such factors, in a manner similar to Doran's work[824] on OPEC member-countries. However, changing political-economic circumstances consistently alter the weights that can be allocated to each variable.[825] Consequently, the systematic application of the analytical criteria, in each scenario, would be only to the extent necessary.

5.2 Analysis of conceivable permutations

Many permutations of uniform pricing and volume control by exporters are conceivable.[826] In this Chapter, however, the author undertakes individual country analyses within two exclusive permutations - Uniform Pricing (UP) and Volume Control (VC) in the Atlantic Basin.

5.2.1 Uniform Pricing (UP) in Atlantic Basin

It is important to reiterate that uniform LNG pricing is a price-fixing agreement, by LNG exporters, to apply the same principle[827] to determine the long term contract price payable by importers. In Chapter Three, a pricing regime was proposed and simulated as a cartel action in Chapter Four to generate the following result summary:

Table 5.3 Comparison of extra rents earned from the application of U.P[828]

[823] Given the "equal cost" assumption, as well as, a common HHI for the LNG market
[824] Doran, C., *OPEC Structure and Cohesion: Exploring the Determinants of Cartel Policy*. Vol. 42, No. 1, Journal of Politics, February, 1980
[825] For instance, Saudi Arabia's perspective on crude oil pricing has varied overtime.
[826] Uniform Pricing (UP) in the Atlantic Basin; Volume Control (VC) in the Atlantic Basin; UP and VC in the Atlantic Basin; UP or VC in the Middle East or Middle and North Africa; or Asia Pacific; as well as, UP and VC in the Middle East or Middle and North Africa; or Asia Pacific.
[827] Indexation based on crude (WTI and Brent) prices (described earlier in sections 3.3 and 4.3.1) with the aim of obtaining higher prices.
[828] The changes in Monthly Revenues presented occurred in the elastic demand scenario. And so, it is different from the inelastic demand scenario (when importers do not respond to UP- induced changes in price) which is captured in Appendix 1. The reason is because, when demand becomes elastic, it activates in

EXPORTERS	*% Δ IN REVENUE*	*% Δ IN MKT SHARE*	% CHANGE IN EXPORT PRICE DUE TO U.P FRANCE	ITALY	SPAIN	UK	U.S.A
ALGERIA	*8.48*	-1.43%	48.62%	57.96%	57.96%	0.00%	37.79%
EGYPT	*-16.16%*	-1.66%	44.81%	11.88%	11.88%	0.00	0.00
LIBYA	*-23.89%*	-0.31%	0.00	0.00	68.67%	0.00	0.00
NIGERIA	*-2.17%*	-0.45%	44.81%	54.27%	54.27%	0.00	3.69%
QATAR	*37.91%*	4.37%	0.00	65.94%	65.94%	40.94%	56.21%
TRINIDAD	*2.92%*	-0.51%	0.00	0.00	50.00%	0.00	24.85%

Given the above and in the light of the analytical criteria, what practical inferences may be drawn to support each exporter's incentive or disincentive to collude? In other words, could the potential monopoly rent sufficiently motivate exporters to agree on a uniform price or volume control scheme? The answer would differ for each country.

ALGERIA

With respect to reserves, production capacity and market share, Algeria would be disposed to a collective pricing scheme. In line with its intention to maximize economic rent,[829] the uniform pricing scenario yields a positive change in revenue and relative market share. Given the cautious approach expected, perhaps, Algeria's low petroleum reserve status does not justify this assertion. It is important to note, however, that Algeria is not a new entrant and more gas discoveries are being registered.[830]

Meanwhile, it may be recalled that Algeria had imposed higher LNG prices on its American buyers in the early nineteen eighties. Perceiving some concerns, the US Government exerted its influence and all contracts based on the new price were suspended – Algeria's effort failed.[831] However, the US government's opposition to the contracts was not the only determining factor in the suspension of almost all

a reduction in imports (markets shares – Column 3) and revenue for some exporters. These results are explained extensively in section 4.3.1.2.

829 Giving credence to the above assertion, the Energy Minister recently expressed Algeria's displeasure over the constraining effects, of long term contracts, on prices (and resource rent).

830 The last four gas discoveries were registered on November 4, 2008 as announced in http://uk.zawya.com/Story.cfm/sidv51n45-3NC01/Algeria%20Registers%20Four%20Gas%20Discoveries/

831 Davis, J.D; Blue Gold: The Political Economy of Natural Gas, Paragraph 3, Page 264, 1984.

LNG deliveries to the US for more than a decade. Actually, US importers resisted the Algerian price (which was crude oil linked) because it was significantly higher than the price of other gas. Besides, deregulation happened in the US and the price of gas collapsed which meant that Algerian LNG was unsellable.[832]

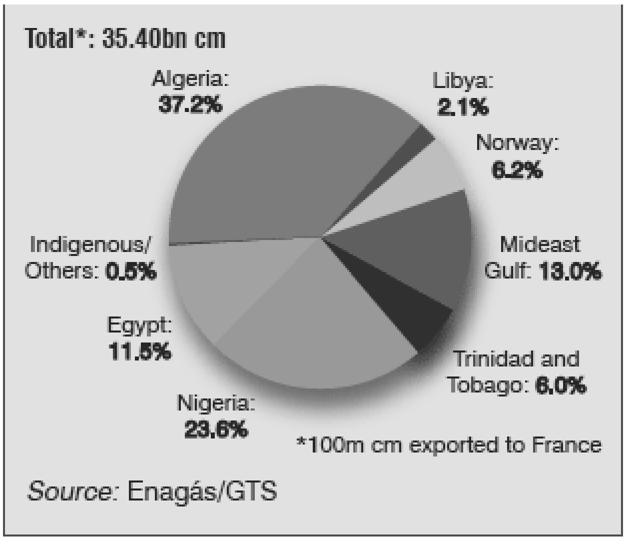
Another important reason why Algeria's effort failed is because a very small volume of LNG cannot be priced independently from pipeline gas in a market where the latter dominates. This can only be done in markets where LNG dominates unless there is collusion by LNG exporters (or between pipeline gas and LNG exporters). While it is apparent that Algeria had a bitter experience then, it is actually possible that Algeria has drawn useful lessons applicable to uniform pricing.

Besides the potential gains realizable, Algeria's major challenge would be how to negotiate the uniform pricing regime into new contracts. Although Algeria has a reputation for bargaining sternly with its European gas customers, if the resultant change in price is too high demand could be destroyed.[833] The simulated worst case scenario indicates such a fall in demand (contracted volume) following the adoption of uniform pricing and price rise of over 48%; 57%; 57% and 37% in France, Italy, Spain and US respectively. Despite the observed fall in demand, Algeria's revenue still rises by about 8% (as Table 5.3 shows).

Its recent successes with Spain[834] and the European Commission[835] notwithstanding, it may still be difficult for Algeria (alongside other exporters[836]) to push through with a new price regime. Unless the new regime is perceived, by importers, as a consequence of their linkage to a globally competitive LNG market[837] rather than a cartel-induced price change. This view is tenable since the marginal price of a globally traded commodity affects its price everywhere.

[832] Details of the Sonatrach/Algeria's price dispute with its US customers are recorded in section 2.2.1.
[833] Arguably, Algeria is the 'lowest cost' supplier of gas to the EU and its proximity to the market is an added advantage.
[834] Twenty percent (20%) staged increase of pipeline gas prices.
[835] Profit Splitting Mechanisms (PSMs) are now allowed on DES LNG sales to Europe.
[836] Figure 5.1, which shows the sources of Spanish gas supply, gives an indication of exporters' market power. A historical view is captured in Table 2.7 and Figure 2.14.
[837] Although LNG is priced differently across regions, the size of Japan's LNG imports, for instance, implies that its price also affects LNG prices in other markets. So, in a globally competitive market, the highest bidder indirectly sets the price.

Figure 5.1 Sources of gas supply to Spain (2007)



Considering that Algeria is a key pipeline gas exporter to Europe, perhaps it could use its market share (export portfolio) as leverage for pushing through a new price regime. Arguably, Algeria is a less important exporter (of pipeline gas) than Norway and Russia but its LNG capacity could provide an edge. Therefore, a pertinent issue which arises is how would such an action impact on (be affected by) current and forecasted demand levels?

On the issue of demand, it is worth emphasizing that domestic gas consumption in Algeria is increasing rapidly. And its new hydrocarbon law is preventing new reserves from being developed rapidly. Therefore, any demand response to the adoption of uniform pricing could be easily absorbed by the domestic market or sold in the spot market.[838] But domestic gas prices in North Africa range between $0.75 and $0.90 per mmBtu[839] – about fifteen percent of the export price.[840] Whether they are able to sell outside or not would depend on the prevailing spot price.[841] If the Spot LNG price is lower than the cartel-based (Uniformly determined) price, then

[838] Algeria has started reserving some liquefaction capacity with the intention of actively participating in short-term trading.
[839] Global Insight, *The LNG market – globally now to 2025 and the implications for the UK*, Report prepared for BERR, October 2007.
[840] For such loss in export revenue, there could be some political gains because some Algerians have argued for reduction in gas exports.
[841] Relative to the long term contracted LNG price (based Uniform Pricing Principles).

sales in the spot market could undermine the UP regime – if buyers know they can avoid paying the UP, they simply buy spot.

There are options for Algeria to hedge against risks, but its integrity would be affected if uniform pricing is perceived as a collective action to influence the market. This may not be peculiar to Algeria but the impact would be more severe given the European Commission's stance on anti-competitive behaviour. Another reason is that Algeria exports gas mainly to Europe.

EGYPT

Egypt had proposed a new pricing formula[842] that would aid producers in planning ahead; save consumers from price fluctuations and ensure stable revenue. The proposal was not accepted, but Egypt may still be interested in a beneficial price determination scheme that meets some of the above conditions. Although the pricing formula applied here meets some of Egypt's criteria, the simulation exercise indicates a loss in market share and revenue (after the change in demand). In a 'lower-demand-elasticity' scenario, the simulation yields an increase in revenue. From a long term perspective, changes in actual or forecasted consumption levels could make demand more elastic and uniform pricing unrealistic for Egypt.

In terms of petroleum status, Egypt is neither a member of OPEC, nor exports oil due to declining production and dwindling reserves. While Egypt – a new entrant to LNG trade – is expected to adopt a cautious approach, this may not be the case. A fact, worth emphasizing, is that Egypt must have considered its proven reserves;[843] liquefaction capacity and spot market options, relative to the risk of loosing market share, before proposing a new price regime in 2004. Egypt exports gas by pipeline and has been active in the spot market.[844] Accordingly, these factors would significantly influence Egypt's disposition towards uniform pricing.

[842] This was proposed to the Gas Exporting Countries Forum (GECF). For more on this, see Wagbara, O. *What are the prospects for a gas OPEC?* International Gas, 2008

[843] As at year 2000, a third of its recoverable gas deposit was reserved for meeting domestic demand for the next 25 years; another third for future generation, while the balance and subsequent discoveries would be exported. It now has an export capacity of 12.2million t/year of LNG and could reach 20.8m t/y by 2010/11

[844] The spot market could be a hedge against any demand-side response.

Egypt, like Algeria, would face the challenge of getting its main LNG buyers in France (Gas de France[845]), UK and Spain to accept the change in pricing. Success in this regard would depend on whether importers can simultaneously transfer price increases to end-users in France, Spain and the UK.[846] Since the Egyptian government is willing to pay higher wellhead gas prices to BG Group,[847] they could easily enforce new LNG pricing rules (in cooperation with other exporters). Besides GdF and BG Group (Centrica) are the main gas utilities in France and the UK respectively and they are integrating backward.

Yes, the prices in existing gas sales contracts are being reviewed, but given Egypt's potential domestic demand, its involvement in uniform pricing can not be justified.

LIBYA

The second lowest cost gas supply available to Europe is through pipeline from Libya but its LNG history has been unstable. Libya's LNG industry started in 1971 and became stagnated due to lack of foreign investments. As a small but re-emerging LNG player, the benefits of a uniform pricing formula (higher prices and more revenue) would seem attractive.

The theoretical expectation, given Libya's high oil-low gas rating, is one of indifference to market influence. Because Libya is initiating new projects and re-establishing LNG trade relations, it would be cautious not to betray investors' confidence or breach contract terms. Considering that sanctions have just been lifted, the expansion of gas production, export and consumption[848] are goals that are dependent on investors' perception of Libya. Besides the above capacity constraints, Libya needs all the revenue it can gather from oil and gas licensing rounds even before new discoveries are exploited. This is especially so, given various economic, socio-political and demographic challenges.

[845] Egypt is GdF's fifth largest supplier with about 10% of GdF's gas supplies.
[846] So far, according to the UK's Office for Gas and Electricity Markets (OFGEM), most Gas majors/retailers/marketers tend to increase prices when necessary but slumps in upstream gas prices are not passed on to end-users.
[847] Operating across the gas value chain, BG Group is the largest producer of natural gas in Egypt – 40% of domestic consumption and 10% of exports (1.5% of GDP as at 2007).
[848] Especially in the area of power generation where new gas-fired plants are being built and existing stations are being converted from oil to gas. Therefore, more oil is made available for exports.

If Libya cannot compete against major Atlantic Basin exporters, could it rather play along with them since they all sell to the same buyers? The theoretically expectation is for Egypt to do nothing since it is very risky. But practically, it could be beneficial to cooperate. Interestingly, the uniform pricing simulation generates almost equal changes in the price offered by Algeria and Libya to their Spanish customers. Comparatively, Libya is not worse-off in terms of extra rent earned and it needs all the revenue accruable from gas exports today. More so, Egypt and Algeria also export pipeline gas which provides vital export partnership opportunities for Libya.

Concerning a possible 0.31% loss[849] in market share, there are arguable justifications for Libya's adoption of uniform pricing. First, it has huge oil revenue to rely on while taking the gamble of uniform pricing along with other exporters. Moreover, it would be risking only the small investments it has made so far without loosing significant market share like others. Third, Libya would only be renegotiating few contracts with mainly Spanish customers after Algeria provides a soft landing. In conclusion, therefore, the expected rise in export price to Spain (from 1 to 68.67%) is a justifiable incentive that is realistic in a cartel context. Meanwhile, Libya is too small to take any significant action on its own - see Table 4.4 – and so it must be a follower not a leader?

NIGERIA

Theoretically, Nigeria's natural gas policy ought to guide its export strategy. As such, Nigeria's potential gain - in the UP scenario - is in tandem with its aim of maximizing revenue from gas.[850] Because uniform pricing increases revenue by 3.69%, it could be an incentive for Nigeria to adopt the mechanism. When viewed against Nigeria's increased involvement in spot sales,[851] a price regime which yields higher income and a possibility of generating spare capacity is attractive.

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[849] As a result of demand elasticity and other assumptions made in the worse case scenario.

[850] Kupolokun, F., *Nigeria and the future global gas market*, Presentation by the Group MD of Nigeria's National Oil Company (NNPC), at the Baker Institute Energy Forum, Houston, Texas on 2nd May 2006.

[851] Next to Egypt (1st) and Qatar (2nd), Nigeria supplied over 17% of the global spot LNG volumes traded in 2008 according to data available in GIIGNL, *The LNG industry*, 2008.

This is because Nigeria trades through spot and long-term contracts. Since, spot LNG prices are volatile[852] perhaps Nigeria is hedging risks (associated with volatility) against more stable long term contract prices. For instance, in NLNG's marketing strategy, spot transactions provide avenues for disposing of excess production and extending the reach of NLNG globally.[853] One could argue, therefore, that it makes economic sense to determine long term prices through uniform pricing – for additional stability. But, going by its reserves status, Nigeria ought to be cautious about applying any cartel mechanism. The challenge of curtailing gas flaring further complicates issues. If flared gas is commercialised, it would enhance Nigeria's petroleum status and disposition towards uniform pricing. The latter assertion holds because the utilisation of flared gas requires a gathering and transmission system - grid. Such infrastructure, which is non-existent today, has dual-effect – it increases Nigeria's gas utilization capacity, as well as, the opportunity cost of exported gas[854] (especially LNG).

Nigeria would, nevertheless, need an Algerian first-move[855] for the regime change to be smooth and effective in Europe. Although Nigeria's LNG export capacity could be more than Algeria's by 2013, it has less market power between now and then. Moreover, Algeria benefits more from the change in revenue (due to uniform pricing) than Nigeria. This is because Algeria is ahead of other LNG producers in terms of exports to Europe. Similarly, Trinidad and Tobago would have to break the LNG pricing ice in North America for others to follow - thereby making it easy for Nigeria to incorporate the uniform pricing regime into LNG sales contracts.

Nigeria's domestic gas demand is expected to increase but there are fundamental challenges[856] to be overcome. Since the worse case scenario indicates a 2.17% fall in revenue and 0.45% loss of market share, the spare gas could also be sold to consumers internally. Although at a lower price but in furtherance of domestic gas

[852] When compared to the price in a long term LNG contract which has a base component.
[853] NLNG, *Marketing: Spot*
[854] With a robust and vigorous domestic gas market (even if upstream only), the cost (price) OF feedstock for LNG projects increases.
[855] The role of a price leader has to be taken and played for any cartel to succeed.
[856] Five major issues are: Fiscal regime for gas; institutional and infrastructural capacity; pricing; financing and regulatory framework.

utilization objectives.[857] Meanwhile, Nigeria's planned exports through the Trans-Sahara Gas Pipeline,[858] offers another opportunity for exporting any extra gas. But this may not happen soon, even though its prospects seem realistic - as highlighted in section 2.3.6. Moreover, Nigeria is not yet a major exporter of pipeline and could be disadvantaged[859] if it opts for the Uniform Pricing Formula.

QATAR

Qatar's GDP has become the fastest growing in the Middle East due to increasing revenue from LNG and its high resource rating.[860] Income from natural gas is expected to exceed crude oil revenues in the next five years. Qatar anticipates that by 2012, the US, Europe and Asia would each be consuming a third of its LNG. Within this context,[861] a new price regime which generates higher revenue and expands market share[862] is attractive from Qatar's perspective.[863]

In market terms,[864] it is justifiable for Qatar to consider colluding – especially if uniform pricing is considered a market-stabilizing mechanism. For Qatar, LNG market stability takes precedence over price transparency.[865] Recent attempts to establish electronic platforms for LNG auctions attest to the fact that Qatar would not sacrifice stability for competitive LNG pricing. Due to the competitive nature of most gas-importing markets an oil-parity LNG pricing system is unsustainable.

Uniform Pricing offers Qatar the opportunity to increase its market power since the emergence of new gas suppliers could alter existing market shares.[866] Moreover,

[857] Nigeria's Gas Master Plan seeks to "optimize Nigeria's share in the high value export market". In accordance with this plan, spare gas could also be sold in the spot market at a higher price over and above the costs of holding spare capacity. The vital issue is yet to be addressed is the price at which gas would be sold domestically.
[858] This on-going pipeline project would enable Nigeria export pipeline gas to Europe through Algeria.
[859] When compared to Algeria, Libya and Egypt that have the option and capacity to export by pipeline. While pipeline exports would not be subject to the Uniform Price, they could serve as hedge against unexpected demand-side responses. For instance, Algeria continued exporting gas by pipeline even after LNG contracts to the US were suspending.
[860] Because of its reserves and production capacity Qatar is now generally regarded reliable supplier.
[861] High gas and low oil reserves.
[862] In a worse case scenario, increases of 37.91% and 4.37% respectively were generated in the simulation.
[863] As previously highlighted in Section 2.3.5 and further discussed in Section 5.3.1 below.
[864] See Table 2.9 where Qatar's 77mt are an imminent reality in contrast to Nigeria's capacity.
[865] An extensive discussion of Qatar's current pricing strategy is presented in Chapter 6.
[866] In the worst case scenario, Qatar could still earn relatively more revenue (up to 37.9%) and market share of over 4%.

Uniform Pricing could serve to protect current investments as demand is threatened by climate change. In a cartel situation, increased supply, from fringe producers, alters the price elasticity of demand and could curtail cartel influence (potential profit).[867] Besides, Qatar needs the higher earnings from Uniform Pricing to balance the lower revenue from LNG sales to Gulf Cooperation Council (GCC) States. The simulation result supports these assertions as Qatar comparatively earns more rent and market share from the adoption of uniform pricing.

It is important, however, to emphasize that Qatar had persuaded European and American legislators to encourage producers through regulatory support for more LNG infrastructure.[868] As the leading producer of LNG, Qatar may be reluctant to lead any anti-competitive effort to control LNG trade and strive to maintain its reputation as a dependable supplier. This view is tenable although Qatar Petroleum hosts the Liaison Office of the Gas Exporting Countries Forum (GECF). Perhaps, without Qatari agreement, no initiative of this kind can work.

TRINIDAD AND TOBAGO

Relative to other exporters, Trinidad's revenue increased even when American and Spanish importers respond to the change in price. The simulation indicates that uniform pricing could be beneficial for Trinidad and Tobago. And it seems that only an infinitesimal part of Trinidad's long term export market could be lost. Like Nigeria, Trinidad and Tobago is a vital player in the spot LNG market where it exercises various exports options. If they blazed a trail[869] by starting the Atlantic LNG project without contracting 100% of the liquefaction capacity, then adopting a new pricing regime for contracted LNG may not be too challenging for them.

Comparatively, after Qatar and Algeria, Trinidad and Tobago stands to gain most from uniform pricing. Consequently, government can achieve its aim of maximizing gas revenues from different avenues[870] and sustaining economic growth through

[867] The extent to which this is plausible depends on the growth rate of gas demand in each importing market.
[868] Mr. Suwaidi of Qatar Petroleum as quoted in the Middle East Economic Survey (MEES) 5 November, 2007.
[869] Trinidad and Tobago has a history of achieving set goals and is a key supplier of LNG to US markets.
[870] This includes LNG exports; investments across the LNG value chain; domestic gas sales; and Petrochemical industry. This could also explain its membership and eventual Presidency of the Gas Exporting Countries Forum in 2005.

diversification of the economy. Based on these objectives, more than 50% of the existing gas reserves are committed to LNG exports.

To the extent that Trinidad and Tobago depends a lot on revenue from hydrocarbons, it would be sceptical about provoking LNG contract pricing issues – not with its major importers in the US.[871] Moreover, in North America, Trinidad's LNG export is a price taker and long term contracts (prices) do not significantly affect domestic gas prices. The reasoning is that Henry Hub-indexed price formula helps North American LNG buyers to sell imported volumes and avoid stranded costs.[872] Besides, Trinidad's robust and expanding economy is putting more pressure on the relatively stagnant gas revenue.

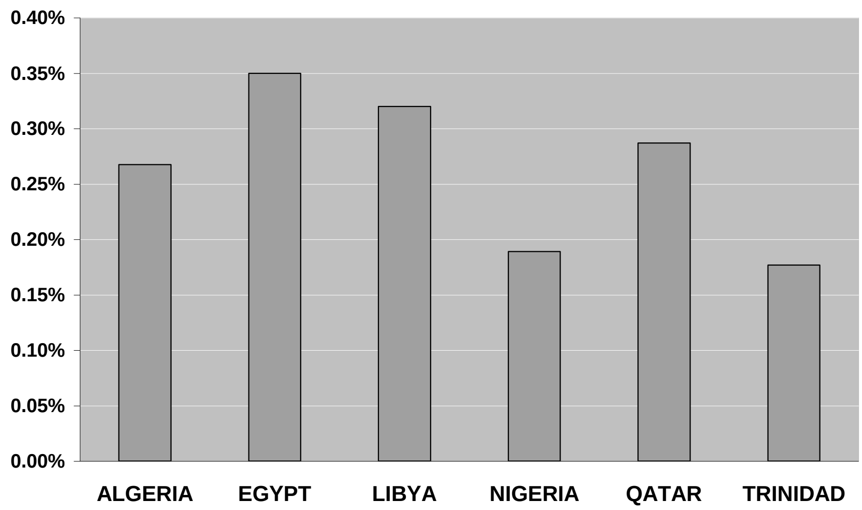
Trinidad and Tobago can partake in a supply-side pricing shock only if the resultant price is lower than or equal to oil price parity. For Trinidad and Tobago, an explanation could be that uniform pricing enables US LNG import prices to trail crude oil price just like natural gas prices do over the long run. Considering its moderate gas reserves, the simulation confirms the theoretical expectation[873] that Trinidad and Tobago is unlikely to adopt uniform pricing. This is especially so because proven gas reserves could run out by 2020.[874]

5.2.2 Volume Control in the Atlantic Basin

Volume Control implies equal percentage reduction in annual contracted capacity, by LNG exporters, with the aim of determining long term prices - aimed at obtaining *higher prices*. Figure 5.2 is a summary of the outcomes generated from the ABLTM.

Figure 5.2 Change in Revenue (%) due to 1% change in Annual Contracted Volume of LNG

[871] Except in collaboration with a larger LNG exporter or a group of exporters
[872] Huitric, R., *LNG Pricing: Impact of Globalization and High Prices on Long Term Contract Negotiations*, Paper presented LNG 15 in Doha, Qatar.
[873] A country with low/diminishing reserves is cautious and less likely to participate in a cartel.
[874] B.P., *Statistical Review of World Energy, 2008.*



The following discourse applies the theoretical framework to the result and analyzes each exporter's perspective of volume control as a cartel mechanism for price determination

ALGERIA

Algeria would be cautious about restricting LNG supplies considering its proven gas reserves. Yes, its revenue increase is more than that of Nigeria and Trinidad.[875] However, Algeria would be reluctant to dent its reputation as Europe's most reliable exporter. An increase in revenue of 0.27% for every 1% reduction in Annual Contracted Volume (ACV), from the simulation exercise, seems good. Yet, Algeria's new preference for mid-term and short term contracts[876] makes the outcome less significant. While the immediate benefits of having mainly short term contracts is apparent, the long run implications for Algeria would depend on the oil price and the level of gas price volatility in the importing markets.

In terms of market share, volume control is economically irrational for Algeria. This is because Sonatrach[877] has gained downstream access to markets in Continental Europe. For instance, Sonatrach entered the Portuguese gas and power generation markets through a joint venture with EDP-Energias de Portugal - Sonatrach gets 25% ownership of three Combined Cycle Gas Turbine (CCGT) plants - one of the

[875] Just after the reduction in Annual Contracted Volume (ACV).
[876] Algeria is adopting a shorter term trading strategy for its natural gas through Sonatrach. The short term (Master) agreements contain neither price formulas nor obligation to buy.
[877] Algerian National Petroleum Company.

plants would be located in Spain.[878] When completed, the Medgaz and Sardinia pipeline projects to Spain-France and Italy respectively would also enable Sonatrach to market[879] gas directly in these countries.[880] These are opportunities for Sonatrach to self-contract LNG or pipeline gas to its downstream subsidiaries/partners and also become an *aggregator.*[881] In this context, why should Algeria withhold LNG supplies if it has opportunities to earn more rent downstream?

Given Algeria's petroleum status, the increasing domestic demand for gas is arguably a justification for reducing exportable capacity. The extra supply of gas could be sold domestically[882] but a stronger argument against Algeria's participation in volume control is its heavy reliance on petroleum revenue.

EGYPT

The Egyptian government recently announced the suspension of the new export contracts,[883] from its share of gas production, until 2010.[884] As stated in section 2.3.2, this restricts Egypt's share of gas production to only the domestic market while suspending new exports transactions either through pipeline or as LNG. It may seem, therefore, that Egypt can forego present incomes for higher prices in future, but this is not the case. First, the moratorium does not affect exports by IOCs[885] and LNG is still a vital source of revenue. So, the need for more revenue could sufficiently hamper Egypt's adoption of volume control.[886]

Second, the policy seems indirectly aimed at reducing pipeline gas exports (especially to Egypt's neighbours) rather than LNG. Third, a unilateral self-imposed

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[878] Alexander's Gas and Oil Connections, *EDP and Sonatrach form power generation and gas joint venture*, Vol. 12, No.8, April 24, 2008.
[879] Sonatrach will be a major shareholder and operator of Medgaz. Although it has been licensed to distribute gas in Spain, it could also sell through its affiliates in London, Spain, as well as, Sonatrach Gas Italia.
[880] Alexander's Gas and Oil Connections; *Sonatrach to start marketing gas in southern Europe*, Vol. 13, No.10, June 3, 2008
[881] Aggregators are LNG venture partners (IOCs and IGCs) who provide trade flexibility through self contracting. Common in the Atlantic Basin, they contract with their subsidiaries to retail gas downstream (in the US or UK) but subsequently become arbitrage agents across the Atlantic or to the Pacific Basin.
[882] At a lesser price - between $0.75 and $0.90 per mmBtu.
[883] Independently - without a cartel quota.
[884] According to Sameh Fahmy (Egyptian Petroeluem Minister) as quoted in Quinlan, M., *Plenty more from Africa*. Petroleum Economist, November, 2008.
[885] Like the plan by BP and Eni to build a 5Million tons per annum LNG Train 2.
[886] Although, Egypt gets the highest percentage increase in revenue, from the simulation exercise

export embargo is distinct from a multilateral cartel-induced reduction in exportable LNG volume. Because the consequence of each exporter's action has mutual implications for others, this issue is very important given the size of Egypt's gas reserves.

Government's willingness to hike the wellhead price of gas could perhaps encourage exploration activities by IOCs since only the government's share of gas production is affected by the export embargo. On the contrary, because only a third of every find is available for export,[887] the amount of investments in exploration and production could fall. While gas supply for LNG and pipeline exports may be affected, the actual impact on long term LNG contract prices is uncertain. It is apparent, therefore, that the above domestic policies would be unfavourable in a volume control situation.

Given the moratorium on exportation of state-owned gas production, it would seem easy for Egypt to adopt the volume control mechanism with other exporters. But, it is important to note that Egypt does not have a lot of gas reserves and exploration activities are being hindered by domestic policies. To the extent that Egypt relies heavily on LNG export revenue, it is unlikely to participate in volume control.[888]

LIBYA

Libya could be reluctant[889] to adopt any mechanism which constrains its export capacity because it is a new entrant and has a relatively insignificant market share. To guarantee their revenue and protect investments, Libya would be keen to maintain good relations with importers. This assertion is tenable despite the simulation result – which indicates that Libya benefits most after Egypt, with a potential 0.32% increase in revenue from a 1% reduction in ACV.

[887] It may be recall from Chapter Two, Egypt's gas policy stipulates that a third of the resource would be used domestically; another third for be kept for future generation and a final third be applied to export.
[888] Unless the significant increase in revenue (as shown in Figure 5.2) can be guaranteed in reality.
[889] Based on economic theory, a new entrant to an industry would be risk averse and cautious about protecting its current and potential market share.

Moreover, new gas discoveries can not be guaranteed[890] even as the government is encouraging exploration activities by IOCs. Since the exploitation of Libya's gas resources and development of its gas sector is hinged on LNG exports, volume control would be counter-productive. This is especially so considering Libya's low petroleum status and existing production capacity. Its oil revenue has been high but, it is an insufficient cushion for the implementation of volume control due to pressing domestic needs.

Perhaps, a cartel of North African or Middle East and North African (MENA) LNG exporters would include Libya but if volume control is the operational mechanism then Libya would not participate. As a new entrant, Libya is yet to play in the spot market but could consider withholding contracted capacity if spot transactions offer higher prices.

NIGERIA

On revenue terms, Nigeria benefits the least (after Trinidad) from the adoption of volume control mechanism, according to the simulation results. One reason for this is Nigeria's long term contracts[891] to US – where domestic gas production is price elastic.[892] The case is, however, different in the Spanish and Italian markets because supply is tight - see sections 2.2.2.2 and 2.2.2.3. Due to a combination of the above factors, Nigeria's revenue increases by 0.18% when the ACV is reduced by 1% in the model. Therefore, Nigeria's involvement in volume control is not plausible from a theoretical standpoint – unless Nigeria focuses more on European markets.[893]

Given Nigeria's participation in spot trade,[894] a mechanism which reduces supply to earn higher revenue would probably be attractive. This assertion is hinged on the current investments in gas exploitation and the following facts: First, Nigeria has

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[890] Given Libya's proven reserves and the interest of IOCs, this may not be a fundamental issue.
[891] Nigeria's LNG exports to the US are indexed to Henry Hub gas prices.
[892] Sections 2.2.1 and 3.1.2.5 discuss the evolution of the US market and pricing respectively.
[893] In the medium term, this would be difficult due to existing contracts (by Nigeria and more important Algeria).
[894] Kupolokun, F., *Nigeria and the future global gas market*, Presentation by the Group MD of Nigeria's National Oil Company (NNPC), at the Baker Institute Energy Forum, Houston, Texas on 2nd May 2006.

many gas projects[895] but insufficient gas production capacity. Moreover, the institutional framework for utilizing flared gas is either inadequate or mismanaged. Another reason is that by reducing its ACV Nigeria would have more gas for other projects or LNG to be traded in the spot market at a higher price.

Nigeria's dependence on petroleum export revenue, however, could be a militating factor against the adoption of such an export restricting mechanism. A cautious approach would seem rational since higher prices are realised from spot transactions[896] and long term contracts guarantee revenue. Risking a steady flow of income for an uncertain increase in revenue, based on a cartel-induced reduction of ACV, could be destabilising for Nigeria. Besides, the security of existing LNG plants is threatened by the prolonged Niger Delta crisis which has also hindered Nigeria's ability to meet its OPEC production quota.

Meanwhile, apart from its membership of OPEC, there is no evidence that Nigeria can meet the economic condition for adopting volume control - forego present gains for higher rent in future. Rather, most of its extra-budgetary earnings (from oil price hikes) are spent[897] amidst the crises in the Niger Delta. Within this context, therefore, Nigeria would cautiously avoid volume control as a mechanism for LNG price determination.

QATAR

Qataris are arguing for the gradual exploitation of gas resources for the benefit of future generations as most Gulf Co-operation Council (GCC) states are facing real or potential gas shortages.[898] For instance, Kuwait and Dubai have added Qatari LNG to their energy mix, while UAE and Oman are experiencing domestic gas shortages.[899] Arguably, this is a reason for the moratorium on new gas export projects and could justify Qatar's adoption of the volume control mechanism.

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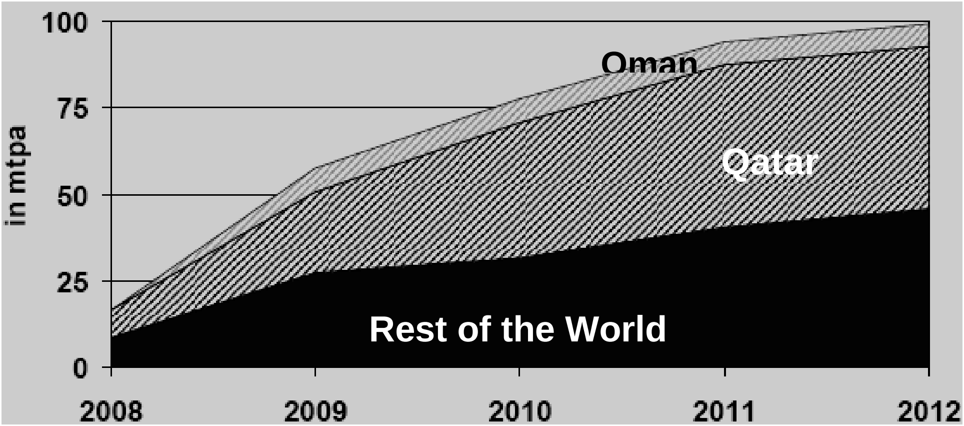
[895] Some on-going and proposed projects include NLNG Train 7 project; Brass LNG; Olokola (OK) LNG; Trans-Sahara pipeline; West African Gas Pipeline Project and other domestic gas utilization projects to generate power.
[896] This would not be the case in an over-supplied market.
[897] An insignificant proportion is sometimes added to the country's foreign reserve.
[898] Dargun, J., *Trouble in Paradise – The Widening Gulf Gas Deficit*, Vol. 51, No.39, MEES, September, 2008 at http://www.mees.com/postedarticles/oped/v51n39-5OD01.htm
[899] *Ibid*

Interestingly, Qatar's LNG revenue[900] increases by 0.28% for a 1% reduction in ACV in the simulation.

Figure 5.3 Qatar's LNG liquefaction capacity to 2012[901]



When the model's result is considered in the light of Qatar's resource rating, an opportunistic approach to volume control is logical based on economic theory. However, given Figure 5.3, Qatar would be very keen to protect its investments; potential export proceeds and trade relations with importers. But what could be learnt from the existing moratorium?

Perhaps, the moratorium on new LNG projects is about a very small state which simply does not need any more money. But, it is also an indication of good reserve management and Qatar's ability to forego present income for future gains. Nevertheless, Qatar is not likely to withhold contracted volumes[902] because it has enormous gas reserves underlying its investments. Therefore, Qatar stands to gain more by keeping LNG markets liquid and stable to guarantee future demand - simultaneously earning revenues from current exports.

Besides, there are fears about future gas supplies for new LNG projects after 2012 because only four projects were approved[903] during the last three years (from end

[900] Revenue from long term contracts as applied in the model.
[901] The graph captures incremental capacity from 2007. Source: Flower, A., *Risk and Responsibility: The New realities of energy supply*, Presentation at Chatham House (Middle East 2008) on February 4, 2008 at http://www.chathamhouse.org.uk/files/11067_0208flow.pdf
[902] Unless, the aim is to export same to neighbours at reasonable but lower prices for non-economic gains.
[903] Final Investment Decision (FID) taken.

2005 to date). Any effort, therefore, to constraint supplies (further tightening the market) would be untimely, giving rise to insecurity of supply or demand. Consequently, instead of venturing into a mechanism that could be detrimental to its LNG future, Qatar would rather consolidate its grip on the LNG industry[904] by expanding[905] its market share. Such a cautious approach towards volume control is practical and rational from Qatar's point of view.

Trinidad and Tobago (TT)

Trinidad and Tobago would need to reconcile the volume control mechanism with its intentions to join the North American Free Trade Agreement (NAFTA) or US-Central American Free Trade Agreement (US-CAFTA).[906] The model reflects a 0.18% in crease in revenue but, the above policy issue is important as government considers investing[907] down the LNG supply chain.

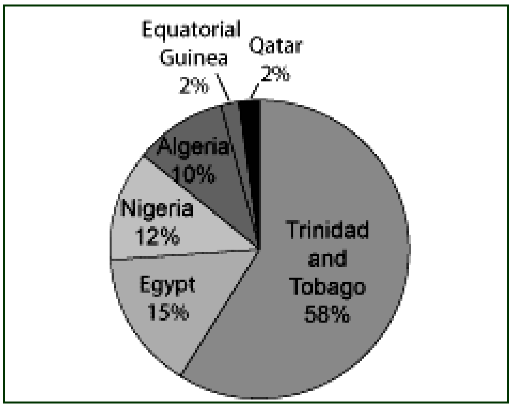
In 2005, Trinidad and Tobago created a Stabilization Fund for LNG export proceeds, while also investing in the expansion of its petrochemical industry.[908] Could this be an indication that it can forego present income for future benefits through volume control? Yes, but there are other considerable implications, of volume control, for the domestic economy because LNG is the country's main revenue earner. In view of government's campaign for more foreign investments across the economy, it is reasonable to argue that volume control would hamper investments in gas exploration.

Another factor what emphasizing is the proportion of US gas supplied by Trinidad and Tobago. Trinidad and Tobago supplied 58% of USA's LNG imports in 2007 (see Figure 5.4). In the context of the US market (about 16.7% of its natural gas consumption in 2007 was imported gas) Trinidad's export volume is relatively small (about 2%[909] of US Gas consumption). Although US Energy Information

[904] The benefits of being a price leader could be a strong incentive to resist.
[905] Qatar can achieve this by selling to more upstream markets and through downward vertical integration.
[906] The potential benefits of bilateral/regional trade agreements are outside the scope of this work - are not discussed any further.
[907] In LNG vessels and regasification terminals, through its National Gas Company
[908] Wagbara, O., *Why does Trinidad and Tobago need a different Fiscal Regime for Gas?* I.E.L.T.R, December 2005.
[909] In 2007, Source: USA EIA; http://tonto.eia.doe.gov/dnav/ng/ng_move_impc_s1_a.htm

Administration projects that LNG imports would overtake pipeline imports,[910] most of the incremental supply would come from other exporters[911] rather than Trinidad.

Figure 5.4 Sources of US LNG imports (2007)[912]



Consequently, a reduction in Trinidad's ACV of LNG may be insufficient to generate the expected price/revenue increase for Trinidad and Tobago in the US. Rather, it would affect basis differential between Henry Hub and individual hubs, as well as, among regional hubs. It is worth noting, however, that irrespective of the source, increases or decreases in LNG supply alter regional price trends. Perhaps, it justifies the need for a price conspiracy by exporters.

Besides, Trinidad and Tobago is not particularly rich in petroleum resources (as indicated in table 5.2). So, even with the cooperation of other producers, it stands to gain almost nothing from future LNG price increases. Since it is relatively disadvantaged and would be the worst-affected by any changes in US demand or fringe supply, a theoretical conclusion is that Trinidad would avoid volume control.

5.3 Winners, Losers and Price Leader

Fully interpreting the long-term outcome[913] of the simulation result is more complex. On the demand side some relative gains resulting from the change in price are probable and notable. Perhaps, following from the above discourse, a natural alliance of like-minded countries could emerge. Given tables 5.2 and 5.3, is it

[910] EIA, *What is liquefied natural gas (LNG) and how is it becoming an energy source for the United States?*
[911] These are mainly Equatorial Guinea; Qatar; Norway and Yemen.
[912] EIA at http://tonto.eia.doe.gov/energy_in_brief/liquefied_natural_gas_lng.cfm
[913] Absolute and relative changes in the revenue and market share of each exporter.

conceivable that winners and losers could adopt similar strategies despite differences in reserves, market share and changes in potential revenue?

In this context, a few possibilities for compensating losers are conceivable. Holding other price determinants constant, exporters could divert cargoes to markets with supply gaps given their relative price advantage - when other markets offer higher price. So the closest loosing exporter to the higher-priced market makes a sale. Another possibility is that a loosing LNG exporter (like Libya/Egypt) could take on the pipeline gas export obligation of a winning pipeline-LNG exporter (like Algeria).[914] Such an arrangement would seem like a delivery swap (between Algeria and Libya) but without a compensating export opportunity from Libya to Algeria. While, a detailed consideration of these and other options for compensating losers (from UPM or VCM) is important, such an exercise is outside the scope of this work.

A more relevant issue, however, is the need for a price leader to balance the opportunistic attitude of gas-rich exporters with the cautious posture of new entrants - with low reserves. Is there a natural candidate and would it be willing to take this position? Who could be the leader and why? Could the emergence of such a leader make it easier for LNG exporters to develop a market control mechanism?

5.3.1 Is there a natural Leader?

Both Algeria and Qatar naturally have the capacity to emerge as controlling leader. Algeria is a major exporter of oil and LNG, as well as, pipeline gas to Europe but its gas reserve is dwindling. Although, Nigeria also has the capacity,[915] it may not command the support of Algeria and Qatar given Table 5.3 and because of its unstable polity[916]. The point here is that whoever is leader will need to have the agreement, or at least not the opposition, of these two countries. Why?

Qatar has the largest liquefaction and shipping capacity (but does not export oil). Moreover, Qatar is strategically positioned in the Middle East – equidistant from the Atlantic and Pacific Basins. In other words, Qatar is the exporter with genuine and

[914] This suggestion presupposes that both countries have adequate infrastructure and capacity to export pipeline and Liquefied Natural Gas.
[915] Based on the data presented in Tables 2.1 and 4.4
[916] Recall Nigeria’s peculiar energy needs and geopolitical challenges as described in section 2.3.6.

immediate access to, and arbitrage between, Atlantic and Pacific Basins. Others have this possibility, but with Qatar's resource base and its established liquefaction capacity, Qatar is the key player in any game of this kind. Although Algeria first attempted a unilateral price increase, Qatar was the first to place a moratorium on new projects. It is difficult to ascertain a country's willingness to lead a cartel but the determinants of Saudi Arabia's influence could suffice.

Existing literature reveals that there are broadly two schools of thoughts on Saudi Arabia's pricing power. While Adelman[917] asserts that no nation can single-handedly harm importers' interest, most economists agree that Saudi Arabia's reserves and spare capacity gives it the capability to lead[918] OPEC. Despite the divergence in opinions, Saudi Arabia's pricing strategy has varied over the years[919]

However, its production decisions and market power are inherently linked to the following: existing spare capacity; energy and revenue needs;[920] as well as, internal security and regional political considerations.[921] For instance, it has been argued that the Saudi government favoured (and still favours) moderate prices as indirect payment for US protection against aggressive neighbours.[922] Perhaps there are parallels here with Qatar in the gas market.

5.3.2 Who and Why?

On the strength of its reserves and liquefaction infrastructure, one could argue that Qatar has more prospects of emerging a natural leader than Algeria. Qatar is politically stable internally but could be susceptible to the same ideological

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917 Adelman, M., *The real oil problem*, in Regulation, spring 2004.

918 This does not imply an exercise of exclusive power in disregard of other OPEC members' preferences. Arguments about the dominant role of Saudi Arabia were expressed in: Mabro, R. *OPEC and the price of* oil. Vol. 13, No. 2, 1992; Doran, C., *OPEC Structure and Cohesion: Exploring the Determinants of Cartel Policy*. Vol. 42, No. 1, Journal of Politics, February, 1980; Mabro, R., *Political and financial aspects of the oil game,* in Erickson, E. and Waverman, L., (Eds.) The Energy Question: an international failure of policy, (1974).

919 No political or economic theory alone consistently explains the changes in Saudi's policies.

920 This is a function of demographics and global economic growth.

921 A comprehensive political analysis is presented in Al-Yousef, N., *Economic Models of OPEC Behaviour and the Role of Saudi Arabia*, University of Surrey, Surrey Energy Economics Discussion Paper Series, No. 94, 1998 at http://www.econ.surrey.ac.uk/Research/WorkingPapers/seed94.pdf

922 Stevens, P., *National oil companies and international oil companies in the Middle East: Under the shadow of government and the resource nationalism cycle*, Vol. 1, No. 1, Journal of World energy Law and Business, 2008.

pressures, as Saudi Arabia, within and out with the cartel.[923] Its foreign exchange reserve is sufficient cushion for sponsoring LNG capacity expansion, while meeting domestic revenue needs.

To effectively determine price Qatar must not reconcile the differences in discount rates among members. Rather, like Saudi Arabia, it has to be a reliable exporter of LNG and defend higher prices only to the extent bearable by the global economy. Whether such a small state could be the political leader of such an LNG initiative is another question – outside the scope of this work.

5.3.3 How to Lead

The challenge for Qatar,[924] therefore, is how it can make uniform pricing more pragmatic from the buyer's perspective.[925] A way to make uniform pricing sustainable, in long term LNG contracts, is to ensure that some economic rent is transferable to buyers (IOCs, IGCs or Utilities). In addition, such LNG buyers should also be able to pass on higher prices to end-users. One could argue that as gas reserves gradually dwindle and production cost rise[926] oil parity could be imposed[927] in the Atlantic Basin. Thereby making the market conducive for the adoption of uniform pricing based on oil parity with Qatar as leader.[928]

It is important to reiterate that with the exception of Spain, Atlantic Basin importers are largely pipeline gas markets with LNG at the margins and pipeline gas sets the price. Apparently, this could change over time because of the imminent globalization of gas trade through LNG and the positive demand outlook described in Chapter Two. Besides, downstream gas prices are already being affected by spot LNG prices, during winter periods, in the US and UK.[929] If this trend continues,

[923] Given diverse regional demand (across the globe), this is one area where, Qatar needs to take pipeline gas exporters into consideration.
[924] Due to Qatar's close links with the West, it would not want its actions to be seen as anti-competitive.
[925] Every pricing formula is acceptable to LNG buyers, provided it offers them opportunity to hedge their market position through buying or reselling and also make money when the cargo arrives.
[926] But the US has large shale gas reserves and the global economic crises could cripple production cost.
[927] It would be termed an imposition because the US has its own price dynamics based on domestic gas, while Europe also has different dynamics.
[928] Beyond Qatar's gas reserves, liquefaction capacity and financial capability, its willingness to lead an LNG cartel is a political decision and its justification requires more rigorous analysis outside the scope of this work.
[929] Pipeline gas does not set the price of LNG all the time.

perhaps, it could result in a defined relationship between long term LNG and downstream gas prices.

Box 5.3 LNG price discovery as gas markets change during winter[930]

Oversupplied Market	**Tight Market**
* Spot trading reveals price < LT[931] contracts	* Spot trading reveals price > LT contracts
* Breaks oil-price link with low prices	* Breaks oil-price link with high prices

The above argument would also depend on LNG demand in the emerging and developing economies across the globe. Meanwhile, it is equally possible that pipeline gas will continue to dominate in many countries. This line of argument may not hold water due to future economic uncertainties and the geopolitics of pipeline gas supply in the Atlantic Basin.

5.4 Conclusion

Generally, there is sufficient evidence that petroleum-rich countries which are risk averse would be more disposed to uniform pricing. Uniform pricing, as a mechanism for price determination, is feasible to the extent that the major exporters (Qatar, Algeria and Nigeria) participate. It is important to note that the extent of its feasibility would depend on its definition or formula.

Theoretically, based on the conditions outlined in section 4.3.3, it would be more difficult to formulate an acceptable pricing formula for exporters than a volume control mechanism. One reason is because the question of how to value long term gas exports has remained unresolved. The “Single Basing Point”, previously used to determine oil prices, is a good example of a failed uniform pricing regime. **In practice**, however, it is not the case due to the peculiarities of LNG trade. Accordingly the following would constrain the adoption of VC:

- High cost of storing natural gas in tankers, pipeline or as LNG in Vessels;
- Technical challenges of constraining gas production or liquefaction
- Exporters have peculiar gas needs for domestic and export markets;

[930] A similar result could be expected from regular spot LNG auctions – as posited in Frisch, M., *LNG market may soon see emergence of regular auctions for spot cargoes,* LNG Journal, April, 2008.
[931] LT refers to negotiated long term contract price.

- Different LNG investments; contracts and projects finance obligations of exporters

So, it would be easy to agree a “crude oil parity” formula,[932] but much more difficult to get countries with different needs to agree on volumes. Besides, it is highly unlikely that each exporting country can reduce the ACV of all long term LNG contracts to generate an increase in price. Furthermore, petroleum rich countries would be less disposed to volume control if existing investments are high. An explanation for the contrasts in theoretical and practical outcomes could be the evolving nature of international resource markets (and cartels).[933]

Yes, a global reference price could emerge for the indexation of LNG, but apart from tradition, supply tightness[934] strengthens the gas-oil price link. Conversely, excess gas supply (weak demand for LNG) weakens the price link. As such, one major factor which could enhance interest in or feasibility of uniform pricing is the falling price of oil or gas. At a given level, LNG price is destructive to demand[935] and could become an incentive for vigorous development of alternative fuels. Though feasible, the long-run effectiveness of uniform pricing (cartel mechanism) could be constrained by end-users’ ability to substitute gas with alternatives. Moreover, the question of how a uniform pricing regime would be implemented is worth considering because long term contracts expire at different periods for different exporters.

Meanwhile, increasing domestic demand is threatening exports as some LNG exporters have either suspended or restricted new export projects to a future date. Algeria and Egypt are committed to building a reputation for themselves. New comer, Libya would rather establish itself in the LNG industry[936] by building a good

[932] Not necessarily as proposed here but based on the same principle(s) – crude oil price parity based on energy content.
[933] Just like several economic theories and statistical models have attempted (but failed to) to explain or predict OPEC behaviour at different times.
[934] The tight supply situation was particularly strong in 2007-08, but given the economic crises, 2009-10 market condition could be different or too early to predict.
[935] It is important to note, however, that the LNG demand curve (like for oil) is responsive to economic growth.
[936] Conversely, the attraction to emulate or collude with its North African neighbours (Algeria and Egypt) may be irresistible.

customer base and meeting its project finance obligations. Given Qatar's existing capacity, huge investments and expected returns, volume control is a difficult sell. But Qatar could play a key role in determining LNG price through the uniform pricing regime.[937]

Conclusively, it is uncertain that a reduction in Annual Contracted LNG Volume would generate significant increase in long term contract prices for each exporter (**within each importing market**). Rather, such a collective reduction in ACV would have the *combined effect* of propelling the price of LNG in the spot market. While this would be beneficial to spot LNG traders, its implication for long term LNG trade is infinitesimal. Only if spot LNG price becomes the basis for contract price indexation, would volume control be a feasible mechanism for influencing LNG trade. But, how realistic is the emergence of a spot LNG price in the Atlantic Basin, Pacific Basin or global market? So far, spot trade remains the mechanism for balancing the market.[938]

A more predictable outcome could be obtained from uniform pricing – where Qatar and Algeria would be pivotal - rather than go on such an adventure. However, some issues on the realism of price control in the Atlantic Basin would have to be addressed. A major question in the case of an Atlantic-based uniform pricing behaviour is the ability of exporters to defend the pricing principles (targets) set by the cartel. Once a collusive system/action is put in place **its sustainability becomes a vital issue.** Yes, there are potential benefits for some exporters but can the participating countries (in such behaviour) ensure sustainability[939] of their actions? Besides, the collective gain through collusion does not seem enormous[940] and some other exporters could loose significantly[941].

One also wonders how UP control would work in North America considering that Henry Hub is an autonomous gas to gas price-setting mechanism. Moreover, LNG

[937] Since its supplies could go anywhere - the US; Asia or Europe.
[938] It would be interesting, however, to know the extent to which spot LNG trade could be affected by VC or UP. This issue is briefly considered in Chapter Six.
[939] In the face of market structures and regulatory frameworks how would UP stand the test of time?
[940] That is as incentive to the exporters to collude - unless other non-economic or long term benefits are considered.
[941] In the event of a demand-side response, as the worse-case scenario indicates.

is not the only available future supply source.[942] So, the likelihood that LNG exporters would significantly control Henry Hub and NBP prices, through UP, is very slim. Unless oil price becomes very low and LNG exporters apply UP to undercut the cost of developing shale gas.[943] For European countries that are substantially dependent on pipeline gas supplies,[944] unless pipeline gas becomes unavailable for long periods, marginal quantities of LNG would not consistently set prices.[945] However, a combination of UP and VC could be adopted by North African exporting countries to defend UP. Perhaps this would be effective in Spain and possibly France – markets which are substantially dependent on imported LNG.[946]

In the above sense, it is conceivable[947] that volume control and uniform pricing would be effective mechanisms for price determination in Asia-Pacific. This assertion is reinforced by the fact that most LNG contracts (within the region) are indexed to the Japanese Crude Cocktail (JCC). One can logically assume that JCC is the uniform price mechanism in the Pacific Basin. And, it is instructive to note that:

- this situation is not and was not due to the setting up of a cartel
- Neither can one assert that it is the consequence of a collective decision by producers
- Rather, it happened for other reasons: Possibly because the markets into which LNG is sold are similar - no pipeline gas[948] and the eagerness to ensure stable supply relative to changing demand.

Maybe, uniform pricing does not necessarily need an exporters' cartel. Or, due to the nature of Pacific gas markets and high price[949] offered for LNG nothing much would be gained from cartelization in the region.[950] Considering the potential

[942] 2-3 years ago LNG seemed the only alternative but now more unconventional gas and renewable energy supply is anticipated. Whether these expectations would materialize in the current climate is another issue.
[943] Shale gas production is likely to determine Henry Hub prices for the next few years.
[944] Spain and France are excluded.
[945] This does not imply that marginal quantities of LNG do not or would not influence domestic gas prices.
[946] Recall the peculiarities of the gas markets in these countries as described in Section 2.2.
[947] Considering the volume of contracted LNG it imports but, subject to further investigation.
[948] As discussed in sections 2.2 and 3.2.3.
[949] Indexed to crude oil price, and a premium relative to prices in the Atlantic Basin
[950] Perhaps, as the market changes the need to defend high prices (through a cartel) in the Pacific could arise. However, these assertions would require additional research to be substantiated.

challenges of imposing UP in the Atlantic Basin, one can logically conclude that a successful and sustained implementation is slim or conditional.[951] Furthermore, it is dependent on LNG achieving a stronger influence on domestic gas prices. But, is it actually possible to separate the two geographical and commercial aspects of the market.

Against the above, Chapter Six captures the direction in which LNG trade is moving and how that relates to the theoretical discourse of the book. It briefly expounds on some potential implications of uniform pricing for LNG trade (spot trade; contracting and project finance).

[951] It is dependent on LNG achieving greater share of gas markets.

CHAPTER SIX

GLOBALISING LNG TRADE AND THE PRINCIPLES OF UNIFORM PRICING AND VOLUME CONTROL

6.1 Initial case for an Atlantic Basin LNG World

At the beginning of this book, the focus was to consider an organization and a price/volume mechanism relevant to Atlantic Basin LNG because the consideration of a global organization/mechanism would be too complicated. It seemed justifiable, then, to assume that gas markets in Atlantic Basin would potentially determine global LNG trade.[952] The assumption was based on: the liquidity of gas markets in North America and Europe; diversified exporters in the region, as well as, Europe's high dependence on LNG.

Since 2007, it is increasingly evident that LNG is becoming – and many would claim has already become – a global market. In 2008, a very substantial amount of LNG (around 30%) which appeared to be committed to Atlantic Basin from Atlantic exporters – and labeled in this book as "Atlantic Basin LNG" - disappeared to the Pacific chasing higher prices.[953] Some cases and corresponding market effects are first presented.

6.2 LNG is a global commodity

6.2.1 LNG trade has begun to globalize

New LNG export contracts indicate that exporters have inserted clauses allowing them to divert LNG to higher price customers if importers refuse to match price terms being offered elsewhere. Meanwhile, Middle East and North African producers (especially Algeria, Egypt and Qatar) have diverted a lot of (hitherto) Atlantic Basin cargoes to Asia-Pacific markets.

Similarly, Qatar has become a pricing bridge between the Atlantic and Pacific Basins due its geographical location and ability to deliver cargoes based on their relative netbacks. Through cargo migration, Qatar secures more rent, when pipeline gas prices are lower than LNG prices in the Atlantic Basin, by allocating additional

[952] The irreversible trend towards globalization of gas trade, through LNG, lies in the Atlantic Basin.

[953] Some evidence of the migration of cargoes is presented in Section 6.2 overleaf.

cargoes to Asia-Pacific buyers. It therefore, combines flexibility with stability (demand security). Due to tight supply in 2007-08, this comparative pricing phenomenon[954] has resulted in the emergence of global spot price for LNG[955] and long term price linkages.

As a global LNG market has emerged the Atlantic Basin and the Pacific Basin can no longer be considered separate entities. Rather, it is necessary that the assumption of an 'Atlantic Basin LNG world' be relaxed to see how the principles of uniform pricing or volume control fits with globalizing LNG trade. The aim is not to resolve what will happen in the LNG market, but essentially, to show the direction in which the market is moving and how it may be related to the topic of the book.

6.2.2 Uniform Pricing Mechanism (UPM) in a global LNG market

Several factors – increased LNG Demand in the Pacific Basin and competition for supplies among buyers in 2007 – are responsible for the developments described above. As Atlantic markets progressively loose cargoes and exporters suspend LNG projects there are notable commercial implications for LNG trade – both buyers and sellers. Up until the second quarter of 2007, HH price seemed an efficient spot market price for LNG in the US and Spain (sometimes).

The initial relationship was disconnected due to market tightness especially between 2007 and 2008. Qatar also contributed in breaking the 'HH-Spot LNG Price' link by negotiating its spot transactions at significant premiums above the Henry Hub.[956] At other times, the higher of HH and NBP is used and a premium applied. Qatar, invariably, hedges more volatile hub-indexed pricing in the Atlantic Basin against more robust oil-based pricing in the Pacific Basin.[957] The strength of this dislocation and the extent to which it affects global spot (and long-term) LNG trade may be too early to predict (correctly).

[954] With some perceived effects on medium and long term transactions.
[955] Harris, F. and Law, G., *Seller's market for LNG set to last*, A Perspective from Wood Mackenzie.
[956] Fesharaki, F., *Asian, global LNG Markets in transition are defining future*, Vol. 4, Issue 3, LNG Observer, July 01, 2007.
[957] Wagbara, O., *To what extent is a liquid LNG Hub, in the Middle East, feasible?* I.E.L.R. Issue 3, 2008

What is pertinent, however, is that the approach[958] is common among LNG exporters. Second, the development of a traded index for LNG seems to have been avoided because the lack of transparency is beneficial to sellers. Moreover, rather than try to create any type of volume/price influence mechanism specific to the to the Atlantic Basin for themselves, it seems that exporters have moved their LNG to higher price markets (and will probably move it back as *relative prices* change).

Whatever the case, could these new arbitrage clauses and trading modes be considered a form of Uniform Price or Volume Control Mechanism? If not, to what extent could the proposed mechanisms fit into a global LNG market? These questions are pertinent and therefore are given further consideration below.

6.2.3 Could the use of diversion rights and "higher price" clauses be considered a form of uniform pricing mechanism?

A simple answer to the above question is 'yes' and 'no'.

Yes, the use of diversion rights and "higher price" clauses could be considered a uniform price mechanism[959]. First, it generates higher prices for LNG exporters that apply it. Although the prevalent strategy does not involve an explicit agreement by exporters to manipulate the market, the outcome indicates some degree of covert understanding by exporters. Second, and more important, the approach – which is hinged on the natural tendency to test the limits of an import market against oil parity[960] - is similar to the principles of Uniform Pricing proposed here.

However, in diversion and "higher price" clauses, reference is made to higher price(s) obtainable in any other market. Therefore, to the extent that such arbitrage clauses do not entail explicit pricing formula, indexed to crude oil price, it is arguable that they can not be considered a kind of Uniform Pricing Mechanism[961]. Besides, post-2008, some LNG cargoes switched from Asia to Europe, not completely for price reasons but because of the recession/lack of demand.

[958] That is, LNG cargo diversion through the use of diversion rights and "higher price" clauses to optimize revenue.
[959] Though not in the manner proposed here.
[960] Huitric, R., *LNG Pricing: Impact of Globalization and High Prices on Long Term Contract Negotiations*, Paper presented LNG 15 in Doha, Qatar.

Moreover, if sufficient undeveloped gas reserves exist in an importing market, a formula-based LNG price regime that is equal to or higher than oil parity is unsustainable. This is because, in a competitive gas world (depending on the prevailing oil price), domestic gas production is triggered even before[962] gas prices reach oil parity. In the US,[963] for instance, conventional and unconventional gas reserves are exploited to compete with LNG imports at certain price levels.

6.2.4 To what extent would the UPM (as proposed) fit into a globalizing LNG market?

This question can be rephrased to capture the key components of a globalizing LNG market – price arbitrage and freedom to transact at any price or place.

- **Can price arbitrage be considered a UPM?**

Arbitrage can not be considered a UPM, but rather could be described as "creating optionality" for three fundamental reasons. In the first instance, price arbitrage is a spot market strategy that is mainly useful from an individual perspective and effective in a competitive market. In addition, price arbitrage is the mechanism that links markets together, as sellers compete for markets and buyers compete for supply in a global market place.[964] In the equilibrating process, highly complex price setting relationships are created across energy (Gas, Oil, Electricity and Coal) markets, as well as, emissions trading markets. Moreover, price arbitrage relies on the difference in prices or pricing regimes across importing markets and allows importers a share of arbitrage rent through profit splitting mechanisms[965].

In contrast, UPM, as proposed here, is the uniform adoption of LNG pricing formula, referenced to competitively determined oil price, in long term contracts (see sections 3.3.2 and 4.3.1). It could fit into a competitive global LNG market, if it is adopted in most LNG transactions. In this sense, only LNG exporters can benefit

[961] In the strict sense, as defined in Chapter One of this book.
[962] Considering the time it takes to complete such gas projects.
[963] However, the US is untypical as there is no other country in the world which imports gas where there is so much undeveloped gas resource.
[964] In the equilibrating process, highly complex price setting relationships are created across energy (Gas, Oil, Electricity and Coal) markets, as well as, emissions trading markets.
[965] Or any other agreed commercial arrangement, between buyer and seller, which encourages cargo diversion (depending on where the importing company is domiciled).

from oil-parity induced price increases but it would interfere with existing price interrelationships (within and across markets).

Nevertheless, it is would be more effective when applied regionally,[966] depending on availability of gas domestically and the nature of the importing market – competitive, managed or regulated. Like in the Pacific Basin, for Japan, Korea and Taiwan, LNG import is the only source of gas supply. For these markets, it will be much easier for exporters to exert considerable price/volume pressure – and as described above, there is some evidence to suggest that they are already doing so with crude oil parity as a uniform price mechanism. But, its introduction was not at the instance or initiative of LNG exporters – as stated earlier in section 5.4.

So for price arbitrage to be considered a UPM, in a global LNG market, it requires a global price marker[967] and must allow exporters to predominantly earn diversion rent. A likely example is the emergence of an exchange-based LNG price index, uniformly adopted[968] by LNG exporters for short and long term transactions. Without speculating on the future, one can argue that JCC is being applied as a UPM *regionally* in the Pacific Basin[969] *and* exporters are using it as bargaining chip for influencing global LNG trade.

Interestingly, such trans-regional arbitrage does not simultaneously generate higher prices for exporters in all markets[970] but provides indirect control. Notably, it agrees with the model result that uniform pricing is feasible but invalidates its direct adoption in the Atlantic Basin (as hypothesized). So, in a global LNG market, the application of UPM in the Atlantic is less likely without a cartel. Similarly, the

[966] Depending on the availability of gas domestically and nature of the market – competitive, managed or regulated.
[967] Or a defined price relationship - like that which exists between WTI and Brent crudes.
[968] On the condition that it guarantees higher prices and remains under the influence of exporters (probably through a Volume Control Mechanism).
[969] The history of LNG markets and pricing in the Pacific is captured in sections 2.2 and 3.2.3(a) respectively, but this research has not investigated whether JCC was a producer or an importer-led mechanism - it is an interesting subject.
[970] Market participants in the UK and continental European have reported that spot prices fall slightly every time the arrival of a vessel at the Isle of Grain is announced.

continued application of JCC as a UPM in the Pacific could become less sustainable without a cartel.[971]

- **Does an arbitrage-based UPM need agreement from an organization of gas exporting countries (Gas-OPEC/GECF)?**

In the event that exporters are allowed to earn or keep a greater portion of arbitrage rent, it is conceivable that an arbitrage-based UPM can be applied without a collective agreement by gas exporting countries.[972] While such may enhance competitive LNG trade, it would be more difficult for exporters to implement.[973] However, given that PSMs – key instruments for rent sharing – are considered illegal and anti-competitive in some jurisdictions, a coordinated effort under an organization would be more secure and effective.

6.3 A Volume Control Mechanism (VCM) in a globalizing LNG market

Exporting countries have begun to impose unilateral volume limits on exports (Qatari and Egyptian moratoria; greater emphasis on domestic gas utilization in Nigeria and Algeria, while Trinidad needs to find new gas). So far, there is no evidence to indicate that these actions/decisions were collectively agreed by exporters. As the LNG trade becomes globalised, however, it would be interesting to know the extent to which restrictions on exports in individual countries could lead to/substitute for a VCM (as proposed).

It is important to emphasize that VCM, as conceived here, is aimed at furthering the course of globalization and arbitrage-based uniform pricing.[974] To a large extent, the eventual culmination of individual export restrictions into a VCM is unlikely because new export projects are either on-going or being proposed. However, such a scenario would depend on the prevailing crude oil price and the level of gas demand in the Atlantic and Pacific Basins. At relatively low oil price and high gas demand, domestic exploitation of convention/unconventional gas reserves becomes

[971] Especially, if a downward trend in LNG demand occurs.
[972] In such circumstance, a pertinent question, however, is whether LNG exporters would be allowed unhindered access to liquid gas markets.
[973] That is, muscle more rent from the International Oil and Gas Companies. The reason is because IOGCs are adopting an integrated approach in their LNG trade and are better equipped/informed for arbitrage.
[974] Through the systematic reduction in contracted capacity (to increase the spot LNG price) while increasing uncontracted liquefaction capacity for arbitrage.

uneconomical relative to LNG importation. Consequently, export restriction by individual countries becomes beneficial to other exporters.[975]

6.4 Could this new LNG world see an evolution towards a combination of UPM and VCM?

Based on the simulation, if uniform pricing or volume restriction is applied alone, it could generate consequences that would require a balancing act to sustain trade. So, depending on the target level/nature of market influence, both mechanisms could be adopted simultaneously to defend or determine the market price.[976]

Judging from market trend, there could be two scenarios in which the new LNG world would see an evolution towards a combination of UPM and VCM. The first scenario could be provoked by policy efforts towards alternative fuels and energy independence,[977] despite a low (falling) price of crude oil. Such policies and related incentives could affect LNG demand and price in some markets. A second scenario is if Atlantic Basin importers continually undercut LNG exporters by diverting lower-priced LNG cargoes[978] to the Pacific Basin at prices lower than oil-parity.

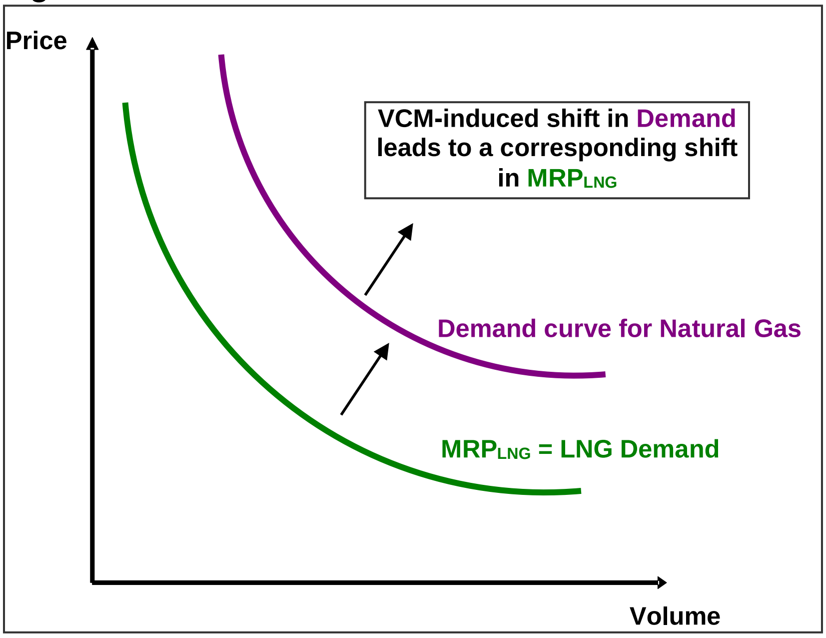
In either circumstance, the current pricing strategy used by exporters would be affected. For instance, Fesharaki argues that "shale gas has put a ceiling on US gas prices" and suggests a change in Qatari LNG pricing policy.[979] Amidst the global financial crisis, one would expect the LNG market to soften considerably, putting pressure on prices[980] - a catalyst for better co-ordination of gas flows in order to maintain prices and potentially leading to delays in new gas projects. In other words, exporters could rely on some form of VCM or UPM[981] to reduce the effects of alternative supplies[982] on LNG - thereby retaining diversion rights, "higher

[975] Relative to the country that withholds exports.
[976] The need arises, therefore, for further research and simulation of this scenario.
[977] Especially in the United States of America (which has large amount of unconventional gas reserves).
[978] Through self-contracting, International Oil and Gas Companies sell LNG to their subsidiaries based on lower indices (HH or NBP).
[979] Fesharaki, F., as quoted in *FACTS sees LNG pricing shift requiring Qatar policy change*, at http://zawya.com/printstory.cfm?storyid=v51n45-2EF03&l=132500081110
[980] The sharp drop in gas prices recorded in 2009 is a classic example of such a scenario.
[981] Not necessarily as proposed here.
[982] For instance, if LNG price is kept low enough then it would make the production of shale gas uneconomical and find a market in the US.

price" clauses and defending the link to crude prices. But, is there a theoretical basis for this conclusion? Yes.

In a competitive buyer market, Dahl posits that, a monopolistic LNG cartel or "seller should sell up to the point where marginal revenue equals marginal cost."[983] When LNG exporters have market power, their Marginal Revenue is below the demand (curve) for LNG in most importing countries/markets.[984] In the importing markets, the Marginal Revenue Product of LNG (MRP_{LNG})[985] defines the demand for LNG.

Figure 6.4 VCM-induced shifts in Demand and MRP_{LNG}



So, for exporters to consistently earn higher prices, they must restrain supply to shift the MRP_{LNG} (demand) curve upward to the right (as Figure 6.4 indicates). To sustain a UPM, the same process would also be required at different intervals, depending on prevailing market situation. Likewise, in a recession (demand is low or shifts leftward)[986], if price reduction does not occur in the importing markets, exporters would need to support demand or price through a VCM.

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[983] Dahl, C.A., International Energy Markets, p.243, para.1, 2004.
[984] This is because LNG has a derived demand which is a function of the demand for its end product/service.
[985] Which is mainly Natural Gas, Petrochemicals or Electricity (depending on the market)
[986] Tietenberg, T, Environmental Natural Resource Economics, 7th Edition, 2006.

In a market where exporters auction[987] new and uncontracted volumes, any supply restricting scheme would make competition for long-term supplies a norm. This, however, could become disadvantageous in some import markets and the ultimate implication for LNG trade would depend on how long such markets can survive the seasonal/perennial hunger for LNG volumes. Then, an alternative source of gas or energy supply becomes the next pertinent question.

It may seem irrelevant[988] but, it is important that the potential implication of Uniform Pricing on LNG trade is addressed here. This is because the extent to which an exogenous influence mechanism could fit into a globalizing LNG market is better appreciated through its potential impacts on LNG trade. Avoiding the temptation to speculate, the subsequent discourse[989] captures the possible effects of UPM (as proposed) on three key elements of LNG trade – Spot trade; Contracting and Project Finance.[990]

6.4.1 How could UPM (as proposed) affect spot LNG trade?

Overtime, sustained and increasing spot trade could develop into a price trend (forward curve) for LNG. Although the real price[991] of LNG remains an illusion[992], such transactions could yield a solution as buyers compete for cargoes. As a long term contract item, the proposed UPM could hamper spot LNG trade if:

- a defined relationship does not emerge between the spot LNG price and crude oil price; and/or
- the number of spot transactions drops significantly.

[987] Offer their LNG to the highest bidder directly or indirectly through the IOGCs.
[988] This work was based on a hypothetical case and the simulation exercise did not find uniform pricing or volume control sustainably feasible.
[989] Some of the arguments presented below were also discussed in Wagbara, O., *What are the potential implications, of exchange-based LNG auctions, for investments in liquefaction capacity?* 28th IAEE/USAEE North America Conference, New Orleans, 2008.
[990] As has been stated in subsection 6.4 above, the proposed Volume Control mechanism is designed to generate more revenue for exporters and ultimately increase competitive LNG trade. Its likely effects, is therefore, not captured.
[991] The real price (supply-demand price) gives an indication of the satisfaction which consumers derive from consuming a commodity, service or its end-product.
[992] Even as the price of long term gas supply is difficult to determine.

6.4.2 How could UPM (as proposed) affect LNG Contracting?

Many energy economists had anticipated that long term contracts and oil-based LNG pricing would be history, but "*LNG has not followed this script".*[993] Rather, contracting has remained an integral part of LNG projects and trade. A general explanation for this is that someone has to take responsibility for servicing the project debt.[994] It is important to note, however, that many regasification terminals – starting with India's Hazira and Dahbol, but now including large numbers of European terminals – have been built without gas supply contracts.[995]

UPM would reduce the amount of time and cost involved in negotiating and renegotiating price formulas in long term LNG contracts because crude oil price is competitively determined. But, in a situation where UPM makes LNG too expensive or affects the sanctity of contracts, the most optimistic solution is a harmonious contract renegotiation. Such an agreeable exercise is hard to come by. Rather contract are renegotiated either through arbitration or mediation.

6.4.3 How could UPM (as proposed) affect LNG Project Finance?

LNG trade has not only become sophisticated with self-contracting, cargo diversions and profit splitting mechanisms, but pricing is more complex. The situation has changed risk profiles along the chain and lenders are now apprehensive that the prevailing trade model involves less secure off-take contracts.[996] In addition, financial derivatives have lost their attraction – after the collapse of Enron - as useful tools for providing price certainty in the long term. Unfortunately, rising project costs, since 2005, is worsening financiers' unease about escalating budgets.

Hub-based gas price indexation could generate more transparent LNG prices, but the fact is that financial risk protection is a concern for sponsors and financiers even in competitive markets.[997] Besides, financiers consider destination flexibility as

[993] Jensen, J., *Comments on Gas Demand, Contracts and Prices*, Oxford Energy Forum, May 2008.
[994] This relates to the capital intensive nature of liquefaction projects.
[995] Rather, they are underpinned by throughput (use or pay) contracts.
[996] Due to the existence of LNG Aggregators: a new role being played by International Oil and Gas Companies (IOGCs).
[997] Either in fully-liberalised gas markets or an LNG Hub: See Jensen, J., *Comments on Gas Demand, Contracts and Prices*, Oxford Energy Forum, May 2008.

potentially more risky when it is advantageous to a party other than the borrower. In this circumstance, a UPM based on oil parity would seem more reliable and could enhance LNG project finance options. Over time we could also see a reduction in the cost of borrowing for LNG projects as financial institutions compete among themselves.

The financing structure of most LNG projects empowers projects sponsors. In other words, "banks and other financing organisations have a significant influence on the pricing terms under which new LNG projects are developed"[998]. So, the collective adoption of UPM by LNG exporters, within a cartel framework, could threaten financiers' confidence.[999] Unless financiers retain the right to, at least, determine the contracted base price for LNG, UPM would hinder the availability of project funds.

6.5 Conclusion

The above interpretation tells only part of the story. This is because the effect of LNG prices or supply on natural gas prices[1000] in importing markets is very complex and can only be answered by running very sophisticated natural gas supply/demand/price models that adjust for the changing logistics of gas supply. So far, it has been demonstrated that the LNG world is bigger than the Atlantic Basin. And, the wider world is already having an impact in the sense that Atlantic Basin exporters are using the Pacific as a substantial outlet for achieving higher prices – from oil price indexation. Attempt was made to reconcile the globalizing LNG market with the principles of uniform pricing and volume control considered in this work.

[998] CIEP., *LNG Impacts on North West Europe*, Summary of Gas Market Seminar, 3 February, 2006.
[999] Between 2004 and 2006 LNG projects secured some of the largest financing deals (even at relatively low margins) due to the high confidence financiers and investors had in the commodity - LNG.
[1000] Not just actual prices but also expectation of future prices and demand.

CHAPTER SEVEN

CONCLUDING REMARKS

7.1 The Question

The literature review[1001] revealed that so far no research on the application of uniform pricing in international gas trade has been undertaken. Although, there are many gas trade models,[1002] none has been designed to specifically consider the sustainability and effects of an LNG exporters' cartel. So, this work attempted to fill the above gaps, while adopting simulation technique and scenario analysis (explained in section 4.1.4).

On the premise of a hypothetical exporters' group, this work considered whether the economics of LNG permits price-setting in the Atlantic Basin. The theory and practice of uniform pricing (as a cartel mechanism) was investigated within the gas industry. To set the scene, the history and nature of pricing in international gas trade was described. The discourse in Chapter Two shows good prospects for LNG in the region[1003] - in the light of declining domestic production, inadequate storage capacity and uncertain pipeline imports.

Chapter Three captured the lopsided interaction between domestic gas markets and LNG pricing. It also demonstrated the underlying and persistent battle (between importing and exporting countries) for the control and character of pricing in international gas trade.[1004] One reason is that most LNG price regimes constrain the maximization of producer rent (as illustrated with Figure 3.3).

Another significant discovery, from Chapter Three, is that the continued indexation of LNG to multiple price indices across regions is certainly not compatible[1005] with the globalization of LNG trade. In addition, seasonal and structural changes in LNG market dynamics push risks upstream and create huge incentives for price

[1001] Literatures were in section 1.6, as well as, in Chapters Three and Four

[1002] See Volume 30, Special Issue (on gas modeling) Energy Journal, 2009.

[1003] During the period up to 2008, but the 2009 global economic crisis may have altered demand trends – the full extent of this still remains uncertain.

[1004] This is due to the theoretical and practical challenges of determining the future price of gas.

[1005] Just like fixed destination contracts is ill-suited to the dynamic world of arbitrage.

determination. So, the author proposed a pricing principle and formula **to test** the feasibility of uniform pricing – a cartel mechanism for price determination.

For simulation,[1006] a set of exporting and importing countries were chosen, from the Atlantic Basin, in a thorough and systematic process with some intuitive sense of representation (in section 2.3). The ABLTM captured the basics of LNG trade and pricing across gas markets in the Atlantic Basin.[1007] By fitting the historical data and iterating the objective function with the same SEED number, probability distributions of changes in revenue and price were generated (see Appendix). From these distributions of outcomes, the most probable scenario for each exporter was extracted. Subsequently, using a theoretical framework,[1008] the probable outcomes for each exporter was contextualized in Chapter Five.

Three key outcomes were obtained from the simulation exercise:

- It uniquely shows the conditions within which the concept of uniform pricing could be applied in Atlantic Basin LNG trade.
- Imposing a Uniform Pricing regime in the region would be difficult due to the marginal role played by LNG in most markets. While this makes sustainability difficult, it also makes collusion essential - to defend prices and resource rent.
- By comparing the outcomes of UP and VC mechanisms, the exercise has offered a deeper understanding of the factors that could determine LNG price in future.

It is noteworthy that the quantitative results obtained are not abstract but theoretically explainable (as presented in 4.3.2.3). Interestingly, the result of the exercise is tenable irrespective of the justification for collusion or the case made for a new price regime. Perhaps, it would be useful to prove that, in a liquid spot LNG market, individual exporting countries would earn more revenue than in the UP and/or VC scenarios.

[1006] Two mechanisms – Uniform Pricing and Volume Control - were proposed and modeled within the Atlantic Basin.

[1007] See detailed explanation of the data, simulation process and results in Chapter Four: sections 4.1.4 and 4.2.2; as well as, Table 4.1 and Figure 4.4.

[1008] The framework was vigorously derived from classic cartel theory in Chapter Five.

Meanwhile, Chapter Five highlighted the hard choices and implications of both mechanisms for each exporting country. From the discourse therein, it is clear that the outcome of the volume control mechanism is beyond the exclusive control of exporters. Most LNG importing countries in the Atlantic Basin will have little difficulty in substituting LNG with domestically produced or imported pipeline gas. So, a collective reduction in Annual Contracted LNG Volume would not significantly increase long term contract prices for exporters - unless a global spot LNG price emerges and is used for long term contract indexation.[1009]

Until now, no constructive effort has been made to determine the primary concerns or incentives for LNG exporting countries to collude. It is apparent from this exercise that, to effectively[1010] apply VC mechanism, the key considerations for any LNG exporting country (or group of countries) should be:

- What is the nature of its export market?
- What domestic pricing regime is prevalent in that/those markets?
- What proportion of the market does it supply?
- What is the LNG sales portfolio of that/those exporting countries?
- What is the long term/spot LNG supply mix[1011] of the importing countries?
- What other potential sources of supply are available to the importing market?
- What determines the long-term price of Gas (LNG)[1012] in each market and at different seasons? If crude oil, then what is the price of oil?

Contrary to theoretical expectation, the above considerations indicate that Volume Control would be practically more challenging. Moreover, gas storage cost is high and exporters have different gas needs; LNG investments; contracts and projects finance obligations.[1013]

On the other hand, it would more practicable for LNG exporters to agree a "crude oil parity" or "energy content" pricing principle. As such, they could exert direct UP influence on markets where LNG comprises a significant part of the gas supply

[1009] However, this is a very optimistic expectation.
[1010] With a significant and sustainable increase in long term LNG price.
[1011] Considering that some countries import more spot cargoes than others, this would determine the individual and collective response of importers to a reduction in ACV.
[1012] This question has remained the object of international arbitration and contract renegotiation.
[1013] It may be recalled that the potentials of each mechanism and conditions for their adoption were presented in Sections 4.3.3 and 5.4.

and indirectly on other markets. But, there may be a difference between choosing a UP which "works" in the current market conditions, and trying to impose a UP which could effectively exclude LNG from the US or some European markets. Perhaps, UP could be extended to only a few, rather than all, importing countries in the Atlantic Basin. Or is that why a cartel is necessary? But, how effective would a cartel driven Uniform Pricing or Volume Control regime be in a global LNG market?

7.2 Limitations of the Study

7.2.1 Approach of the Book

Incorporating spot LNG contracts into the model would have made the results more comprehensive. Another probable alternative would have been to contrast the gains of a cartelised long term contracts market with competitive spot LNG trade. For clarity and thoroughness, this effort considered pricing in long term LNG contracts only. Due to data constraints and small number of spot deals it was not practicable to capture spot LNG trade in the simulation. Besides, there is no defined relationship between short term and long term LNG trade. To make up for this limitation, the analysis in Chapters Five and Six highlights the implications, of UP/VC mechanism, for spot LNG trade.

In the course of this work, legal issues imminent from the influence mechanisms were not considered. Rather they were assumed to be non-existent. This was deliberate in order to stay focused on the economics of gas (especially LNG) pricing and geopolitical cartel behaviour. Given the findings of this work, it would be interesting to approach the underlying questions from an international economic law perspective or the economics of contracting.

The issue of whether another approach could have been better, ultimately, depends on the research question. If, for instance, the book was focused on how the proposed mechanisms could be implemented, then a legal perspective could be appropriate. The robust approach used here is very insightful and appropriate. Besides, the framework used here could be adopted to investigate the feasibility in a global market for emissions permits. In other words, could a standard pricing regime enhance the global tradability of carbon permits?

7.2.2 Scope of the Study

In 2005, it seemed that an investigation of market influence mechanisms in a less-than-definite global LNG market would be inconclusive. However, if one were to start the research again - given the experience of 2007-08 and the globalization of LNG trade - one would certainly include the Pacific Basin in the scope. One vital reason is because of the very large share of LNG in the gas demand of many Pacific Basin importers - UP or VC are very likely to be extremely effective.[1014] Without such elaborate analysis, the research outcome could seem partial. Perhaps, this is one limitation of the work, but also an indication that no one can know the future. To bridge this gap, Chapter Six reconciles the regional outcome with the real world.

7.3 General Conclusion

It appears that it is statistically feasible for exporters to adopt a uniform LNG pricing or volume control mechanism. Theoretically, Volume control would be easier to collectively restrict the production of a commodity to provoke a price increase… It would be practically easier for exporters to agree on a pricing principle than collectively restricting LNG production. But, the extent to which either scheme could be used sustainably to determine LNG price, however, depends on demand.[1015] More so, in a soft LNG market with low gas prices. The reason is that LNG prices drop drastically when gas demand is low in countries where market-based pricing apply. In this regard, both mechanisms are vulnerable in a soft Atlantic Basin market situation.

However, such a market situation, *if global*, could also motivate exporters to take steps to defend LNG price. Judging from the underlying assumptions of the model, adopting either a uniform pricing or volume control regime for LNG in the Atlantic Basin would need close and consistent monitoring of oil prices; gas storage levels; cost and capacity levels along the LNG value chain; as well as; the number and nature of spot transactions.

[1014] Besides, with time, it is almost certain that a defined relationship would result from the interaction of regional LNG (gas) prices.

[1015] That is demand (or supply gap) provoking increase in the proportion of LNG in the total gas supply within importing markets.

For exporters to influence Atlantic Basin LNG trade with either mechanism, the rationale for profit-sharing has to be determined.[1016] And in both scenarios, the distribution of the profits among the exporters would be very complex. Second, any uniform LNG pricing regime must consider the 'basis risks' within competitive national and regional gas grids.

So, until the above underlying questions are resolved, uniform pricing for LNG, in the Atlantic Basin is not feasible in the medium term. Moreover, the complexities of contract price negotiations and the importance of long term contracts[1017] could make uniform pricing, as a mechanism for market influence, impracticable. And LNG trade could become more diverse in the region - in terms of any "standard" pricing formula and in trade patterns. The application of uniform pricing or volume control mechanism is, however, conceivable in spot LNG trade[1018] and in the Pacific Basin where LNG is the only source of gas supply. While, a price-fixing agreement may not enhance LNG's reach into many markets, it would give exporters a stronger negotiating edge.

7.4 Further Research

This innovative effort has contributed to the body of knowledge[1019] by applying the principles of uniform pricing in international gas trade. Beside its originality, the book comprehensively addressed specific questions with results that could be adopted to explain other trends in LNG trade. In addition, it has justified the need for more research in some areas highlighted below.

[1016] By reaping profit on the basis of quotas or sharing equally or by a combination of both.

[1017] This explains exporters' refusal to participate in regular auctions of LNG cargoes and subsequently uniformly adopt the exchange-generated price in other transactions.

[1018] And if adopted could change spot LNG price determination globally.

[1019] The following peer-reviewed publications/presentations have resulted from this work and are major additions to existing literature: (a) Wagbara, O., *What are the potential implications, of exchange-based LNG auctions, for investments in liquefaction capacity?* Paper presented at the 28th IAEE/USAEE North American Conference, New Orleans, 2008; (b) Wagbara, O., *To what extent is a liquid LNG Hub, in the Middle East, feasible?* Issue 3, International Energy Law Review, 2008; (c) Wagbara, O., *To what extent could an LNG export organization, operating a uniform pricing or volume control mechanism, influence LNG trade in the Atlantic Basin?* Paper presented at the 27th IAEE/USAEE North America Conference, Houston, Texas, 2007; (d) Wagbara, O., *How would the Gas Exporting Countries Forum influence gas trade?* Energy Policy Journal, Volume 35, Issue 2, February 2007, Pages 1224-1237; (e) Wagbara, O., *Atlantic LNG trade: What are the implications of the Russian-Ukraine-EU trade row?* Volume 14, No.3, USAEE Dialogue, November 2006.

Simulation results in this work could be improved by adding spot transactions in the model across the Pacific and Atlantic Basins. In future, simulations could be undertaken, though more challenging, to comprehensively analyze Uniform Pricing in a global LNG market which includes Asia-Pacific exporters and importers. Despite prevalent constraint in liquefaction capacity, determining the extent to which competitive fringe supply[1020] could reduce the benefits of UP or VC would be a worthwhile extension of this book.

The *question* of how LNG prices interact with and affect the basis differentials and/or price level within importing markets requires thorough investigation. Little or no research has been done in this area, especially with respect to the UK, US and Continental Europe. Such an exercise could also use specific demand elasticity indices, from relevant sectors of the importing economies,[1021] to precisely capture demand-side response to each mechanism.

This book analyzed the principles of uniform pricing and volume control in LNG trade. But, the exercise only looked in detail at the Atlantic Basin - mostly during the period of supply tightness up to 2008. One has not been able to look comprehensively at the Atlantic and Pacific Basins over a sufficiently long period of time during the globalization of the LNG market. So researchers now have the opportunity:

- to look at the Pacific Basin in the same detail in relation to the possibility of UP and VC
- to examine how, in a surplus market scenario, opportunities for UP and VC will change and
- to look in more detail to see whether there are countries or subsets of countries from both Atlantic and Pacific Basins (like Japan, Korea, Taiwan and Spain) in which UP and VC could work - even if it could not necessarily be extended to all importing countries.

Despite the issues for further research identified above, this work has achieved its stated objectives. Also, it has presented a set of analytical model and framework

[1020] Higher export volumes and/or price-cutting behaviour.
[1021] By decomposing gas demand into the following: Households; Power Generation and Petrochemical Companies.

that incorporates the economics of long term LNG pricing; monthly export volumes and pipeline gas markets (for elasticity). Moreover, the suggested mechanisms provide the basis for explaining the current pricing and trading strategy of exporters in the emerging global LNG market.[1022] Besides, it would prove useful for a better systematic study of the LNG industry in future.

[1022] For instance, in Chapter Six, it uniquely applies the Uniform Pricing proposition to **interprete** probable collusion in the emerging global LNG market.

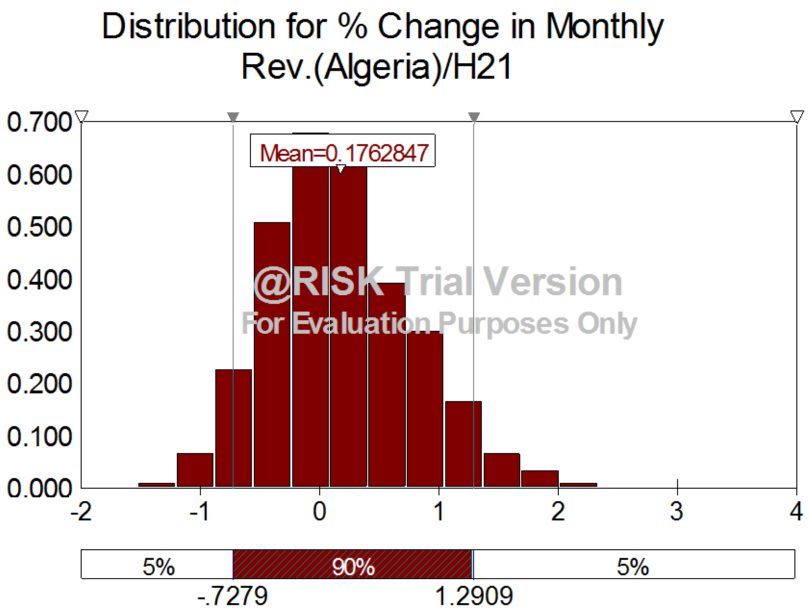
APPENDIX

This Appendix is a guide to help readers understand the book and simulation (results) better. As described in Chapter Four,[1023] Atlantic Basin LNG Trade **(ABLT)** is modeled here as a static representation of long-term LNG contracts captured on a monthly scale. Given the mechanisms simulated (UP and VC), the Appendix is divided into three sections - to capture the results, as well as, present the data used in the exercise. There is an introduction in each section, but generally, Appendix 1 contains results of the UP scenario, Appendix 2 shows the VC scenario outcomes and Appendix 3 describes the dataset used.

1. Change in Monthly Revenues of exporters in the Uniform Pricing Scenario

Following the collective adoption of the Uniform Pricing Proposition (Formula) in the Model, this section of the Appendix shows the initial changes in each Exporter's monthly revenue - as probability distributions. The changes in revenue, presented here, occurred in the inelastic demand scenario – that is importers are yet to respond to the UP-induced changes in price.[1024] So, as cross-referenced in section 4.3.1.2, there are six probability distributions – one for each exporter. The respective mean values are applied to the elasticity indices (in Appendix 3.4) to generate the results in Table 4.3 - page 186

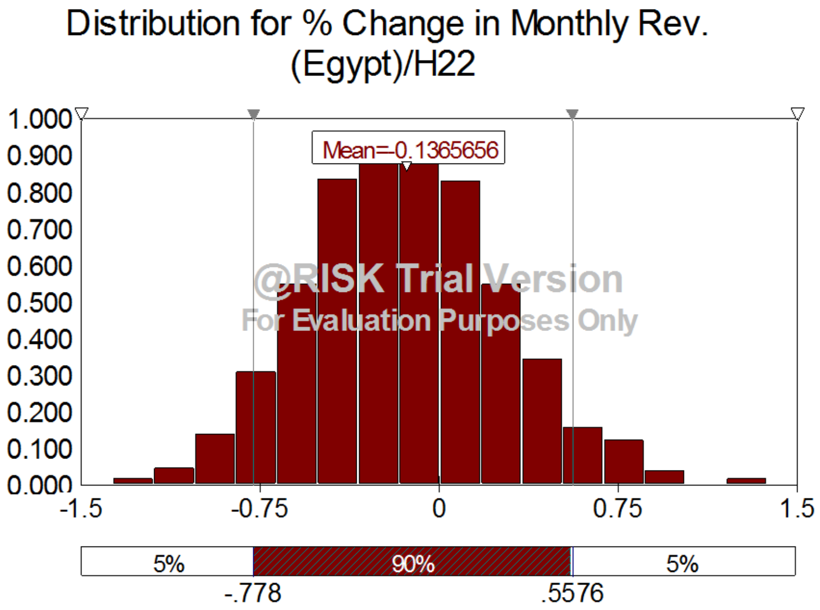
1a)



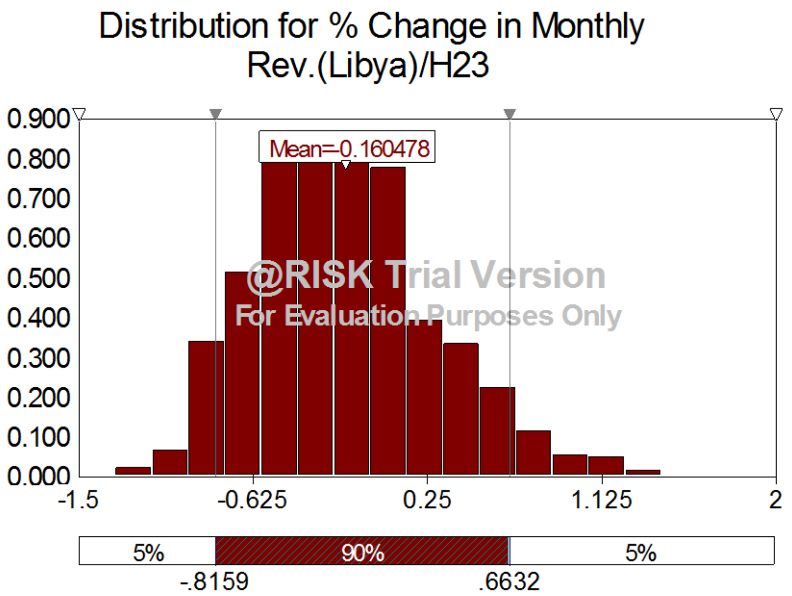
[1023] See section 4.2 – Model Framework, page 173.

[1024] However, the situation is different when demand becomes elastic (resulting in a reduction in imports - Annual Contracted Volumes). The result of the elastic demand scenario (using the elasticity indices described in Appendix 3 below) is shown in Tables 4.3 and 5.3 with the respective reductions in market share.

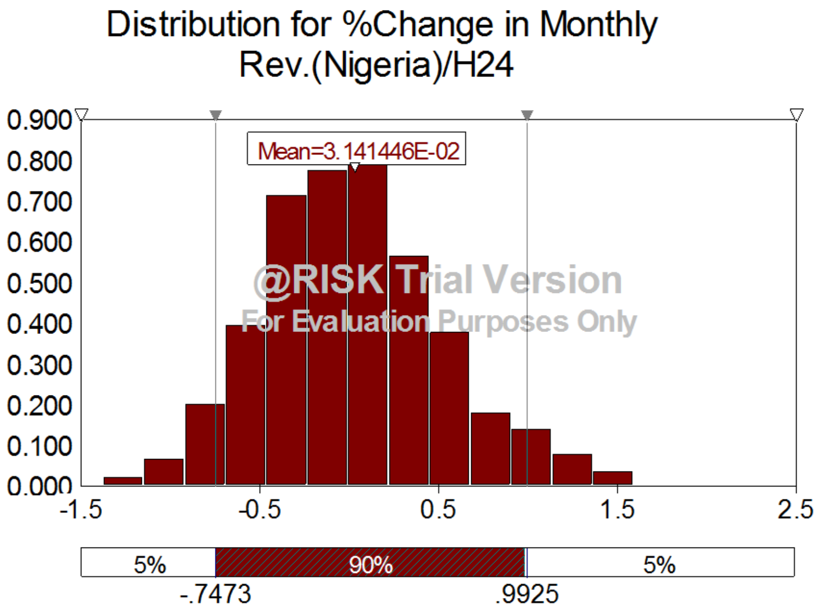
1b)


Distribution for % Change in Monthly Rev.
(Egypt)/H22
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
Mean=0.1365656
@RISK Trial Version
For Evaluation Purposes Only
-1.5
-0.75
0
0.75
1.5
5%
90%
5%
-.778
.5576

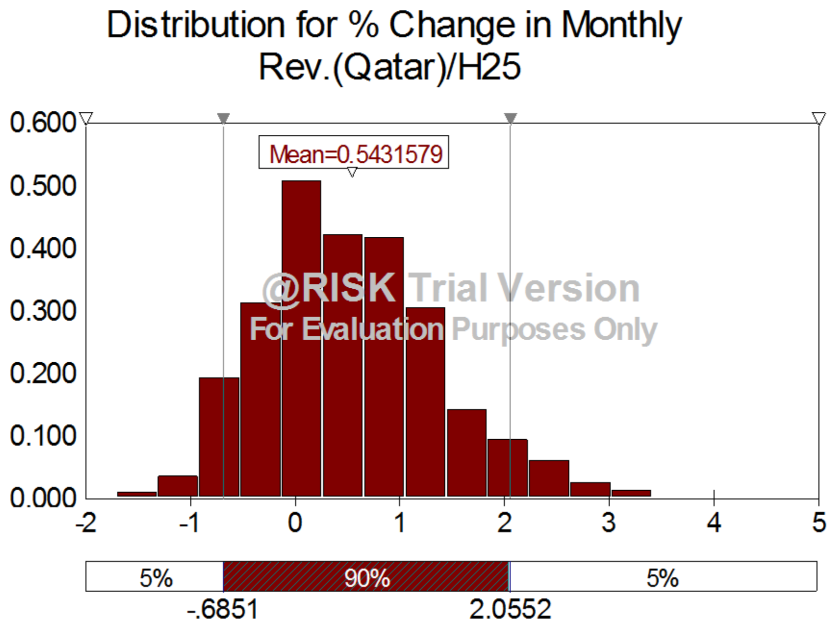
1c)


Distribution for % Change in Monthly
Rev.(Libya)/H23
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
Mean=0.160478
@RISK Trial Version
For Evaluation Purposes Only
-1.5
-0.625
0.25
1.125
2
5%
90%
5%
-.8159
.6632

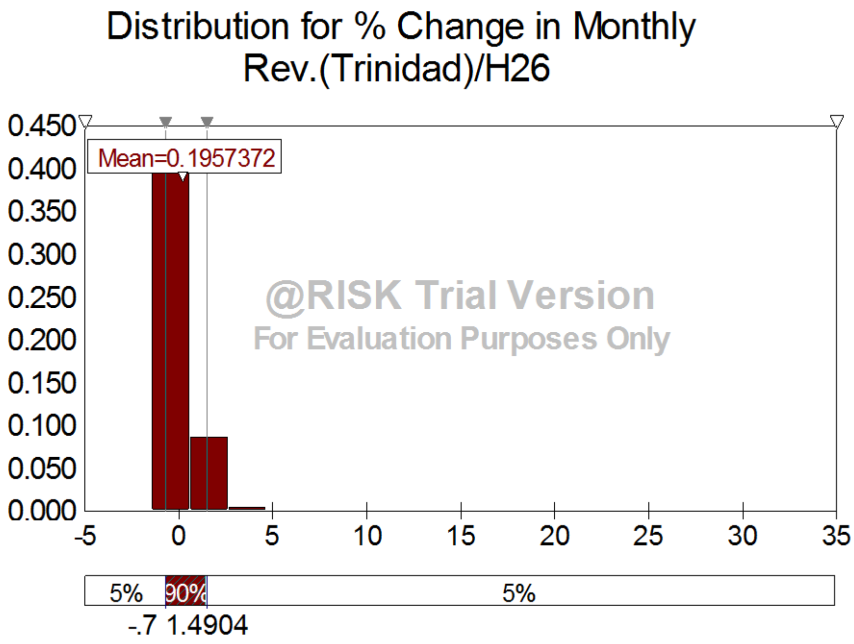
1d)


Distribution for %Change in Monthly Rev.(Nigeria)/H24
Mean=3.141446E-02
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
-1.5
-0.5
0.5
1.5
2.5
5%
90%
5%
-.7473
.9925

1e)


Distribution for % Change in Monthly Rev.(Qatar)/H25
Mean=0.5431579
0.600
0.500
0.400
0.300
0.200
0.100
0.000
-2
-1
0
1
2
3
4
5
5%
90%
5%
-.6851
2.0552

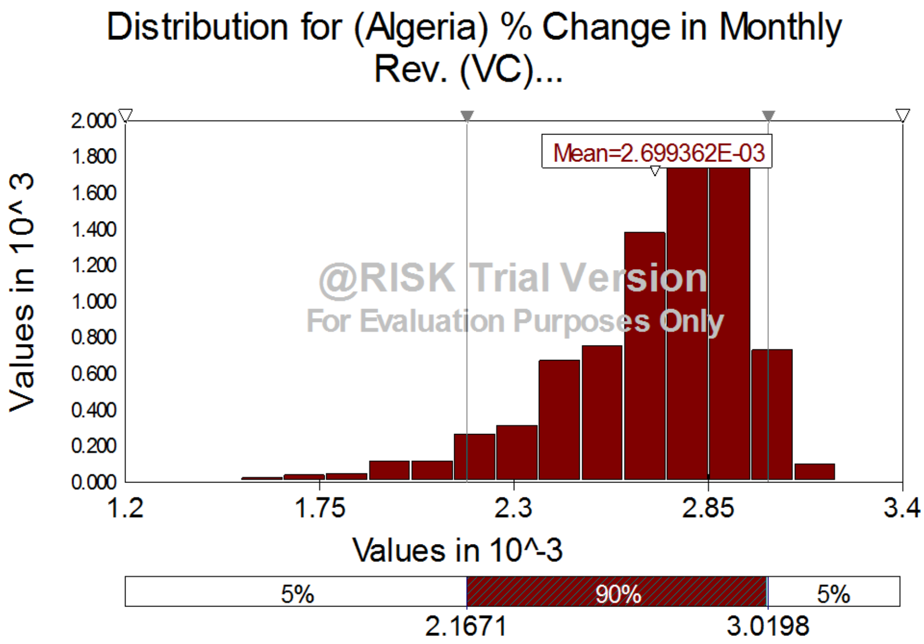
1f)



1. Change in Monthly Revenues of exporters in the Volume Control Scenario

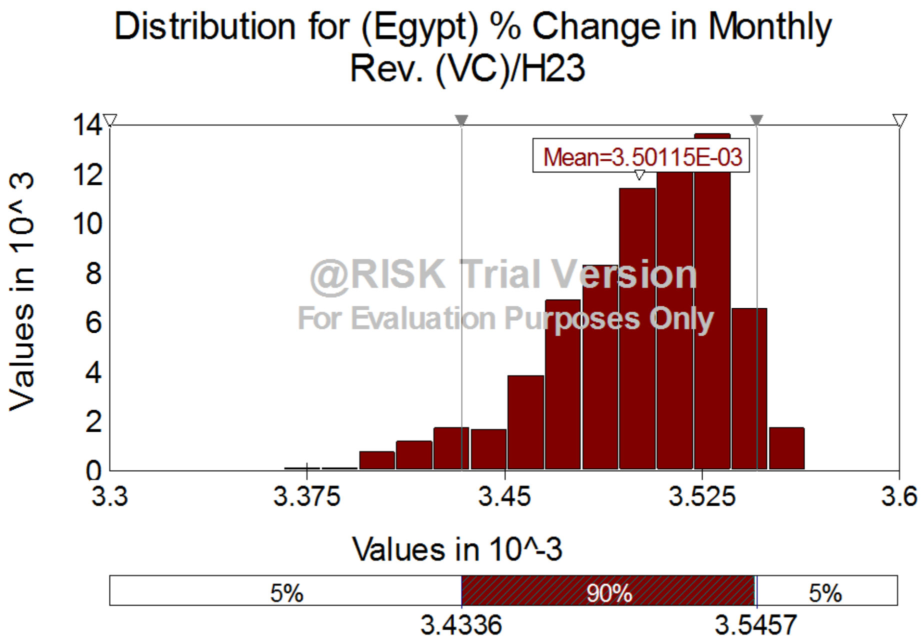
Like Appendix 1, this section shows the outcomes of the VC scenario - cross referenced in section 4.3.2.2 on page 194. The mean values of these probability distributions – one for each exporter - are applied to specific elasticity indices (Appendix 3.4) and each country's contracted volume is constrained by δ% to determine specific increase in LNG price (ΔP).[1025]

2a)

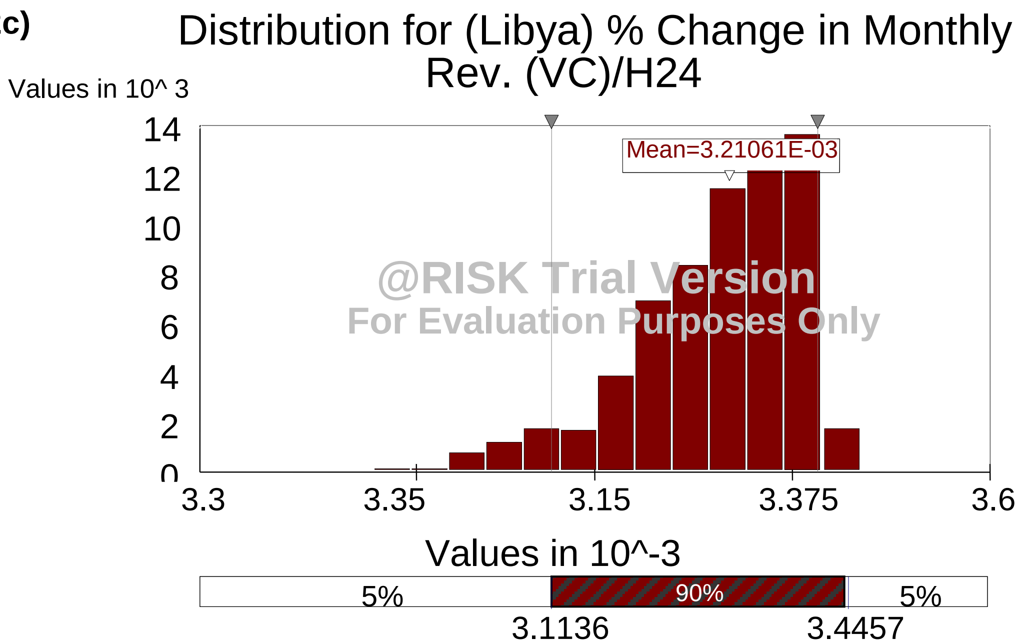


[1025] The Volume Control Scenario and its underlying assumptions are described extensively in section 4.3.2, page 192. Figures 4.5 and 4.6 summarize the outcomes.

2b)

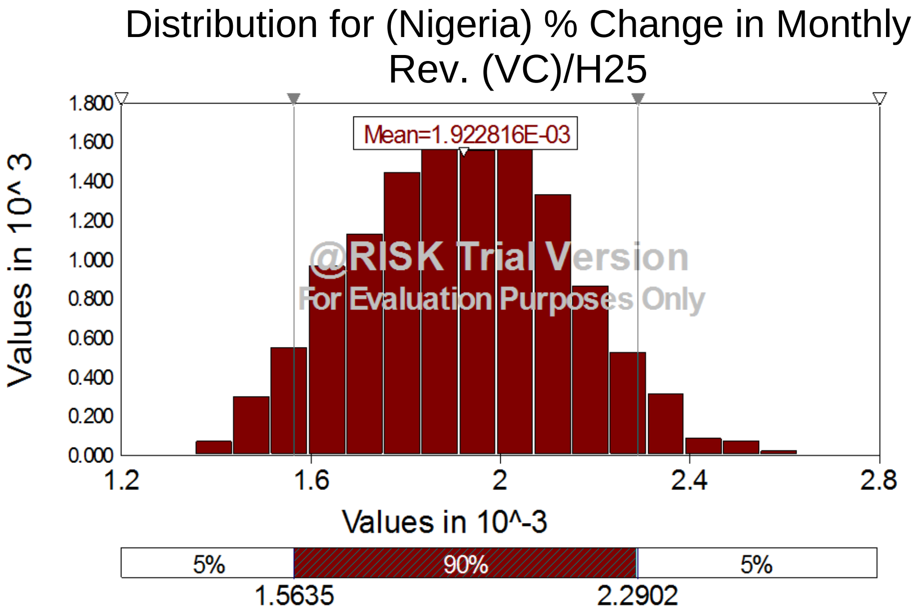


2c)

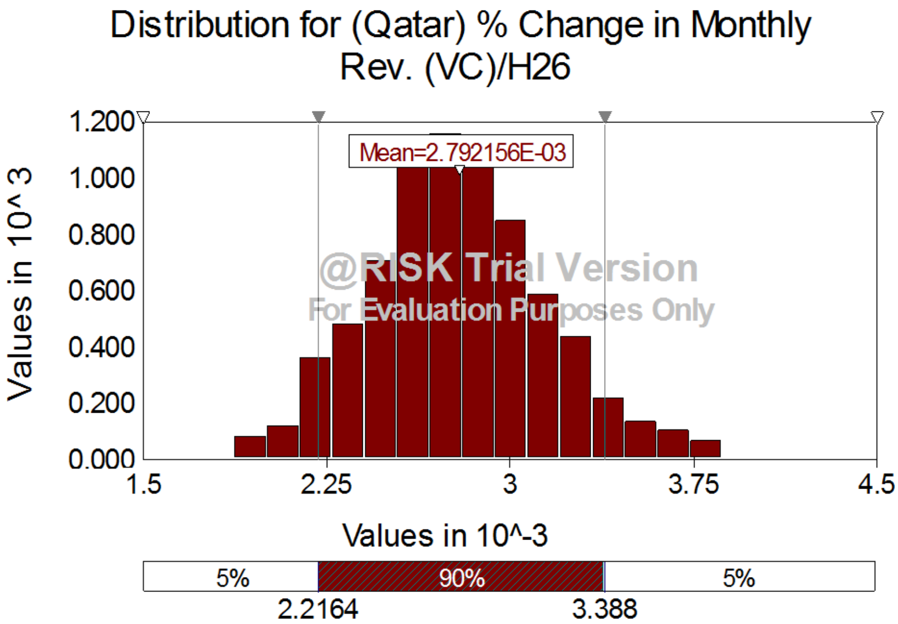


The probability distribution for the change in Libya's revenues yielded errors for Skewness and Kurtosis. This error could be traced to the number of inputs (contracts) iterated for Libya in this scenario. As could be seen in Appendix 3.1, Libyan LNG is contracted only to Spain – on long term basis.

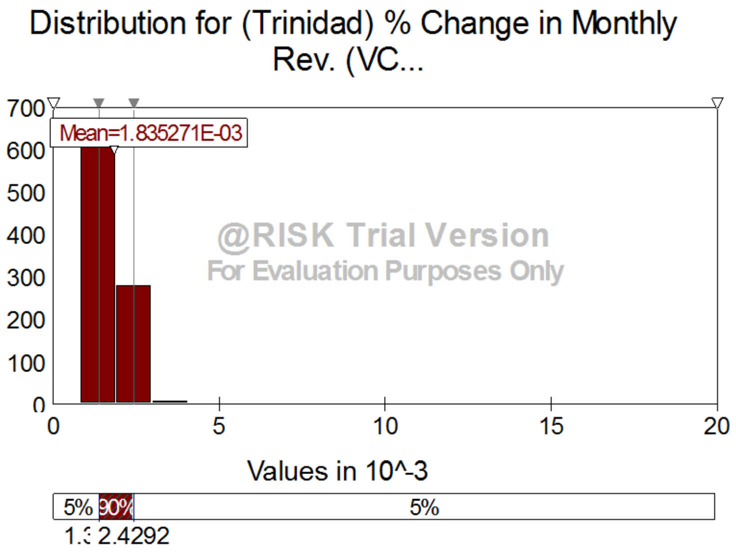
2d)


Distribution for (Nigeria) % Change in Monthly Rev. (VC)/H25
Mean=1.922816E-03
@RISK Trial Version
For Evaluation Purposes Only
Values in 10^ 3
1.800
1.600
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
1.2
1.6
2
2.4
2.8
Values in 10^-3
5%
90%
5%
1.5635
2.2902

2e)


Distribution for (Qatar) % Change in Monthly Rev. (VC)/H26
Mean=2.792156E-03
@RISK Trial Version
For Evaluation Purposes Only
Values in 10^ 3
1.200
1.000
0.800
0.600
0.400
0.200
0.000
1.5
2.25
3
3.75
4.5
Values in 10^-3
5%
90%
5%
2.2164
3.388

2g)



3. STATISTICAL APPENDIX

Given the above set of results, it is important that one presents the data used and explain the source. The following sub-sections are aimed at achieving both the former and the latter. The contracts data, crude oil prices and other confidential LNG price data used in this book were sourced from a reputable organization in the LNG industry – Gas Strategies.[1026] To further enhance their robustness, the LNG contracts used here were contrasted with data held by another reputable firm of consulting energy economists - Jensen Associates Incorporated (managed by Prof. James T. Jensen).[1027] The contracts were verified because they form an integral part of the simulation exercise – in all the scenarios. LNG contract prices could not be verified due to the confidential nature of price data.[1028]

3.1 CONTRACTS VOLUMES[1029]

The Contract data below was used to compute the Annual Contracted Volumes (ACV) of LNG in the Model. These contracts are within the scope of the research[1030] – exact contract dates have been excluded for confidential reasons. In the ABLTM, ACVs are averaged into monthly volumes to generate average monthly revenues for each exporter. A limitation of using such averages is that it ignores seasonal variations in gas demand. However, the six-month average applied evens out seasonal price fluctuations and so any underlying effects on price/revenue are ignored in the simulation exercise.

1026 Gas Strategies Online: www.GasStrategiesOnline.com
1027 http://www.jai-energy.com/
1028 This is in sharp contrast with Crude Oil prices and exchange rate data that could be sourced easily from the trade press.
1029 Gas Strategies Online: www.GasStrategiesOnline.com
1030 The ABLTM covers contracts between 2005 and 2013.

3.1a LNG Contract Data

Exporter	Location	Country	Importer	Country	Volume (mtpa)	Volume (Bcm)
Algeria						
Sonatrach			GDF	France	0.39	0.53
Sonatrach			GDF	France	0.77	1.06
Sonatrach			GDF	France	2.56	3.50
Sonatrach			Gas Natural	Spain	2.77	3.80
Sonatrach			Cepsa	Spain	0.73	1.00
Sonatrach			Iberdrola	Spain	0.73	1.00
Sonatrach			Endesa	Spain	0.73	1.00
Sonatrach			Snam	Italy	1.31	1.80
Sonatrach			Tractebel LNG	United States	0.88	1.20
Sonatrach			Statoil	USA	0.73	1.00
Sonatrach			*Sempra*	*USA*	*1.83*	*2.50*
	France	**Spain**	**Italy**	**USA**		
Algeria's Total (mtpa)	**3.72**	**4.96**	**1.31**	**3.43**	**13.42**	**18.39**
Egypt						
Egypt LNG			Gaz de France	France	3.60	4.93
Egypt LNG Train 2			BG	USA/Italy	3.60	4.93
SEGAS			Union Fenosa	Spain	2.41	3.30
SEGAS			BG		0.76	1.04
SEGAS			Petronas(ALTCO)		0.76	1.04
SEGAS			BP		1.06	1.45
Egypt's Total (mtpa)	**3.60**	**4.99**	**3.60**	**0**	**12.19**	**16.70**
Libya						
Brega Pet. Mkt.			Gas Natural	Spain	0.73	1.00
Libya's Total		**Spain**			**0.73**	**1.00**
Nigeria						
Nigeria LNG T1 & T2			Enel	France	2.56	3.50
Nigeria LNG T1 & T2			Gaz de France	France	0.70	0.50
Nigeria LNG T6			*Endesa*	*Spain*	*0.73*	*1.00*
Nigeria LNG T6			*Shell Western*	*Spain/US/Mex*	*3.00*	*4.11*
Nigeria LNG T1 & T2			Gas Natural	Spain	1.17	1.60
Nigeria LNG T4 & T5			Iberdrola	Spain	1.10	1.50
Nigeria LNG T3			Gas Natural	Spain	1.97	2.70
Nigeria LNG T4 & T5			Shell Western	US/Mexico	1.10	1.50
Nigeria LNG T4 & T5			Total Gas & Power	EU/USA	0.22	0.30
Nigeria LNG T4 & T5			BG	USA	2.50	3.50
Nigeria LNG T6			*Total Gas & Power*	*EU/USA*	*0.88*	*1.20*
Nigeria LNG T7			*BG*	*USA*	*2.25*	*3.08*
Nigeria LNG T7			*Eni*	*USA*	*1.37*	*1.88*
Nigeria LNG T7			*Total*	*USA/Mexico*	*1.37*	*1.88*
Nigeria LNG T7			*Shell Western*		*2.00*	*2.74*
Nigeria LNG T7			*Occidental Energy*		*1.00*	*1.37*
Brass LNG			*BG Gas Marketing*	*USA*	*2.00*	*2.74*
Brass LNG			*BP*	*Italy*	*2.00*	*2.74*
	France	**Spain**	**Italy**	**USA**		
Nigeria's Total (mtpa)	**3.26**	**7.97**	**2.00**	**14.69**	**27.91**	**37.84**
Trinidad						
Atlantic LNG			Tractebel LNG	USA	1.75	2.40

Atlantic LNG			Tractebel LNG	USA	0.22	0.30
Atlantic LNG			BG	USA	1.50	2.06
Atlantic LNG			BG	USA	1.61	2.20
Atlantic LNG			BG	USA	0.80	1.10
Atlantic LNG			Gas Natural	Spain/USA	0.73	1.00
Atlantic LNG			Repsol	Spain/USA	0.66	0.90
Atlantic LNG			Repsol	Spain	1.68	2.30
Atlantic LNG			Gas de Euskadi	Spain/USA	0.73	1.00
	France	**Spain**	**Italy**	**USA**		
Trinidad's Total	**0.00**	**3.80**	**0.00**	**5.88**	**9.68**	**13.26**
Qatar						
Qatargas			Gas Natural	Spain	0.70	0.96
Qatargas			Gas Natural	Spain	0.70	0.96
Qatargas			BP	Spain	0.75	1.03
Qatargas			Gas Natural	Spain	1.46	2.00
RasGas			ENI	Spain	0.88	1.20
RasGas train 2			Endesa	Spain	0.80	1.10
RasGas (II) Train 4			*Edison*	*Italy*	*4.60*	*6.30*
Ras Gas (II) Train 6 & 7			*ExxonMobil*	*USA*	*15.60*	*21.37*
			ExxonMobil	*UK*	*7.80*	*10.69*
			Total	*UK*	*5.20*	*7.12*
			QP/ExxonMobil	*UK*	*2.60*	*3.56*
	U.K	**Spain**	**Italy**	**USA**		
Qatar's Total	**15.60**	**5.29**	**4.60**	**15.60**	**41.09**	**56.29**

Gas Strategies Online: www.GasStrategiesOnline.com

3.2 CRUDE OIL (BRENT AND WTI) PRICES AND EXCHANGE RATE

Crude oil prices were used to generate the Uniform Prices applied in the UPM Scenario. As such, the historical crude oil price data is presented below. Also, presented in the table are monthly exchange rate data which were used to covert NBP price from p/th to $/mmBtu (100,000 Btu = 1 Therm).

Date	Brent FOB ($/bbl)	WTI Midland ($/bbl)	Exchange Rate ($/£)
Jan-96	**17.93**	**18.80**	1.5305
Feb-96	**17.98**	**19.09**	1.5365
Mar-96	**19.95**	**21.33**	1.5273
Apr-96	**20.93**	**23.51**	1.5153
May-96	**19.10**	**21.24**	1.5148
Jun-96	**18.43**	**20.45**	1.5418
Jul-96	**19.64**	**21.32**	1.5540
Aug-96	**20.56**	**21.93**	1.5506
Sep-96	**22.64**	**24.00**	1.5596
Oct-96	**24.16**	**24.90**	1.5861
Nov-96	**22.69**	**23.72**	1.6626
Dec-96	**23.92**	**25.41**	1.6651
Jan-97	**23.45**	**25.13**	1.6586
Feb-97	**20.82**	**22.19**	1.6246
Mar-97	**19.06**	**20.96**	1.6094
Apr-97	**17.46**	**19.75**	1.6296
May-97	**19.07**	**20.91**	1.6333

Jun-97	**17.58**	**19.28**	1.6448
Jul-97	**18.52**	**19.63**	1.6703
Aug-97	**18.64**	**19.93**	1.6035
Sep-97	**18.44**	**19.78**	1.6017
Oct-97	**19.89**	**21.27**	1.6330
Nov-97	**19.15**	**20.18**	1.6891
Dec-97	**17.10**	**18.30**	1.6603
Jan-98	**15.12**	**16.69**	1.6356
Feb-98	**13.95**	**16.07**	1.6408
Mar-98	**13.06**	**15.10**	1.6621
Apr-98	**13.45**	**15.32**	1.6730
May-98	**14.44**	**14.93**	1.6378
Jun-98	**12.05**	**13.69**	1.6509
Jul-98	**12.04**	**14.12**	1.6438
Aug-98	**11.95**	**13.39**	1.6339
Sep-98	**13.39**	**14.97**	1.6823
Oct-98	**12.64**	**14.42**	1.6951
Nov-98	**10.96**	**12.95**	1.6619
Dec-98	**9.88**	**11.29**	1.6706
Jan-99	**11.13**	**12.48**	1.6515
Feb-99	**10.23**	**12.00**	1.6277
Mar-99	**12.50**	**14.66**	1.6219
Apr-99	**15.33**	**17.34**	1.6098
May-99	**15.22**	**17.74**	1.6148
Jun-99	**15.82**	**17.90**	1.5949
Jul-99	**19.03**	**20.08**	1.5747
Aug-99	**20.31**	**21.27**	1.6063
Sep-99	**22.45**	**23.88**	1.6244
Oct-99	**22.01**	**22.69**	1.6573
Nov-99	**24.55**	**24.88**	1.6213
Dec-99	**25.57**	**26.11**	1.6146
Jan-00	**25.55**	**27.26**	1.6394
Feb-00	**27.89**	**29.39**	1.5999
Mar-00	**27.26**	**29.86**	1.5805
Apr-00	**22.59**	**25.78**	1.5834
May-00	**27.63**	**28.80**	1.5087
Jun-00	**29.80**	**31.88**	1.5089
Jul-00	**28.49**	**29.71**	1.5088
Aug-00	**30.11**	**31.33**	1.4902
Sep-00	**32.73**	**33.89**	1.4356
Oct-00	**30.91**	**33.02**	1.4511
Nov-00	**32.58**	**34.40**	1.4256
Dec-00	**25.26**	**28.35**	1.4639
Jan-01	**25.66**	**29.56**	1.4778
Feb-01	**27.45**	**29.56**	1.4530
Mar-01	**24.42**	**27.18**	1.4454
Apr-01	**25.71**	**27.40**	1.4353
May-01	**28.51**	**28.61**	1.4264
Jun-01	**27.83**	**27.57**	1.4014
Jul-01	**24.58**	**26.43**	1.4139
Aug-01	**25.74**	**27.40**	1.4368
Sep-01	**25.57**	**26.08**	1.4634
Oct-01	**20.49**	**22.08**	1.4517

Nov-01	**18.98**	**19.59**	1.4358
Dec-01	**18.68**	**19.27**	1.4390
Jan-02	**19.48**	**19.68**	1.4319
Feb-02	**20.22**	**20.66**	1.4230
Mar-02	**23.73**	**24.35**	1.4240
Apr-02	**25.66**	**26.26**	1.4435
May-02	**25.33**	**26.74**	1.4597
Jun-02	**24.13**	**25.33**	1.4863
Jul-02	**25.81**	**26.71**	1.5547
Aug-02	**26.66**	**28.06**	1.5378
Sep-02	**28.38**	**29.56**	1.5561
Oct-02	**27.58**	**28.73**	1.5574
Nov-02	**24.10**	**25.98**	1.5723
Dec-02	**28.67**	**29.35**	1.5855
Jan-03	**31.32**	**32.84**	1.6169
Feb-03	**32.67**	**35.50**	1.6084
Mar-03	**30.54**	**33.34**	1.5836
Apr-03	**24.85**	**28.03**	1.5740
May-03	**25.72**	**27.84**	1.6223
Jun-03	**27.51**	**30.29**	1.6605
Jul-03	**28.35**	**30.36**	1.6223
Aug-03	**29.79**	**31.23**	1.5941
Sep-03	**27.08**	**27.99**	1.6131
Oct-03	**29.65**	**30.13**	1.6787
Nov-03	**28.73**	**30.74**	1.6900
Dec-03	**29.87**	**31.91**	1.7518
Jan-04	**31.23**	**33.90**	1.8233
Feb-04	**30.83**	**34.03**	1.8673
Mar-04	**33.79**	**36.51**	1.8266
Apr-04	**33.25**	**36.44**	1.8021
May-04	**37.80**	**40.05**	1.7868
Jun-04	**35.04**	**37.88**	1.8275
Jul-04	**38.32**	**40.65**	1.8428
Aug-04	**43.04**	**44.68**	1.8203
Sep-04	**43.25**	**45.74**	1.7921
Oct-04	**49.64**	**53.09**	1.8065
Nov-04	**42.84**	**48.14**	1.8603
Dec-04	**39.53**	**42.94**	1.9278
Jan-05	**44.23**	**46.46**	1.8777
Feb-05	**45.37**	**47.58**	1.8870
Mar-05	**52.91**	**54.11**	1.9058
Apr-05	**51.82**	**52.79**	1.8960
May-05	**48.56**	**50.01**	1.8542
Jun-05	**54.39**	**56.45**	1.8178
Jul-05	**57.58**	**58.90**	1.7509
Aug-05	**64.12**	**65.27**	1.7946
Sep-05	**62.91**	**65.82**	1.8081
Oct-05	**58.61**	**62.06**	1.7640
Nov-05	**55.17**	**58.39**	1.7341
Dec-05	**56.91**	**59.62**	1.7455
Jan-06	**63.05**	**65.49**	1.7678
Feb-06	**60.12**	**61.52**	1.7468
Mar-06	**62.09**	**62.84**	1.7435

Apr-06	**70.35**	**69.56**	1.7696
May-06	**69.83**	**70.96**	1.8680
Jun-06	**68.69**	**70.83**	1.8429
Jul-06	**73.66**	**74.44**	1.8448
Aug-06	**73.11**	**73.21**	1.8946
Sep-06	**61.71**	**63.95**	1.8847
Oct-06	**57.79**	**58.79**	1.8756
Nov-06	**58.92**	**59.09**	1.9119
Dec-06	**62.32**	**62.37**	1.9630
Jan-07	**53.68**	**54.44**	1.9587
Feb-07	**57.43**	**59.20**	1.9581
Mar-07	**62.15**	**60.62**	1.9420

Source: Gas Strategies Online: www.GasStrategiesOnline.com

3.3 SHIPPING COST ASSUMPTIONS[1031]:

A summary of transportation cost (in USD per MMBTU) to *deliver* 15.60mtpa of LNG from Qatar to the US, using a 215,000m^3 capacity vessel is given below:[1032]

Ship cost	0.76	/MMBtu
Fuel cost	0.23	/MMBtu
Boil off cost	0.13	/MMBtu
Suez cost	0.15	/MMBtu
Port cost	0.03	/MMBtu
Total	**1.30**	**/MMBtu**

Source: www.GasStrategiesOnline.com

The above breakdown was useful in arriving at an assumed value for transportation in the U.P Formula: $1 per MMBtu because Qatar to the US is the longest distance which any of the chosen exporters can cover within the Model.

3.4 ELASTICITY INDICES

The price elasticity of final demand for natural gas, in each European market, is adjusted to determine the index for LNG: In the Volume Control Scenario, based on the work of Holz et' al[1033], each country's index is increased/decreased by 0.05 (against the regional index: -0.7) depending on the share of natural gas in the importer's energy mix (i.e. +0.05 for relatively low gas consuming countries and vice versa).[1034] Relying on Holz and Pavel[1035] elasticity of US natural gas demand (-0.90) is used to determine the price elasticity of LNG demand. Unlike Holz and Pavel, however, U.S elasticity is adjusted by

[1031] See shipping cost assumptions on page 174.
[1032] Source: Gas Strategies Online. Transport cost for specific volumes and to different destinations is available from the same source: www.GasStrategiesOnline.com
[1033] Holz, F. et' al *A Strategic Model of European Gas Supply (GASMOD)*, 2006 Discussion Papers of DIW Berlin 551, DIW Berlin, German Institute for Economic Research
[1034] Substitutes affect the elasticity of demand. Due to the peculiarity of each importing country different elasticity indices have to be applied.

0.1 in absolute value to account for the[207] decrease in North American conventional gas production and increasing share of gas in the U.S energy mix. In the Uniform Pricing Scenario, the natural gas elasticity indices are further adjusted, by the percentage of LNG supplied to each market (to determine the corresponding effect of a change in LNG price). Appendix 3.4a shows the elasticity indices (ψ), while Appendix 3.4b shows the data used to generate them.

Appendix 3.4a Natural Gas Consumption (Bcm), LNG Trade[1036] and Elasticity Indices

	Total LNG Imports (Bn cubic metres)	**Gas Consumption[1037]** (Bn cubic metres)	**LNG as a % of N.G**	**Natural Gas Elasticity**	**LNG Elasticity**
USA	**16.56**	619.7	2.67%	0.90	0.02
France	**13.88**	45.2	30.74%	0.75	0.23
Italy	**3.10**	77.1	4.02%	0.70	0.03
Spain	**24.42**	33.4	73.16%	0.75	0.55
UK	**3.56**	90.8	3.92%	0.70	0.03

Appendix 3.4b Determination of Elasticity Indices for LNG

	LNG Imports From							**2006***			
To↓	**Tri. & Tob.**	**Qatar**	**Algeria**	**Egypt**	**Libya**	**Nigeria**	**Total imports**	**Gas Demand***	**% of LNG**	**Natural Gas Elasticity**	**LNG Elasticity**
USA	10.85		0.49	3.60		1.62	**16.56**	619.7	2.67%	0.90	0.02
France			7.35	2.30		4.23	**13.88**	45.2	30.74%	0.75	0.23
Italy			3.00	0.10			**3.10**	77.1	4.02%	0.70	0.03
Spain	3.00	5.00	2.80	4.80	0.72	7.10	**24.42**	33.4	73.16%	0.75	0.55
UK	0.60		2.00	0.96			**3.56**	90.8	3.92%	0.70	0.03
TOTAL EXPORTS	**16.25**	**31.09**	**24.68**	**14.97**	**0.72**	**17.58**	**61.52**	*** From BP Statistical Review 2007**			

Source: Cedigaz (provisional) 2007 (Billion cubic metres)

In testing the feasibility of UP and VC, the above elasticity indices were used to generate the simulation results (presented in Tables 4.3 and 5.3; Figures 4.5 and 4.6, as well as, Appendix 1 and 2).

3.5 CONVERSION

The box below contains conversion measure/units applied in the book.

1 tonne of LNG = 51.7 MMBtus
1cubic feet Nat Gas = 0.028317 cubic metres Nat Gas
(Price (p/therm) x Exch. Rate £-$) ÷ 10 = Price ($/MMBtu)
1000 cubic feet = 1031 Btu
1Mn tons of LNG = 1.38 Bcm of NG

[1035] Holz, F. and Pavel, F., *Will there be enough for everybody?*
[1036] Source: Cedigaz (provisional)
[1037] BP Statistical Review of World Energy 2007

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