André Dorsman · Timur Gök
Mehmet Baha Karan *Editors*

Perspectives on Energy Risk

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Preface

The US is the epicenter of an energy renaissance in oil and natural gas production that is taking place all over the world. This is a far-reaching game changer for the energy industry that will shift and strengthen the economies of the most important energy producing countries in the world. This contrasts dramatically to the opposite situation that occurred just 40 years ago, in the 1970s, when the world underwent the largest energy price shocks of modern times due to the OPEC oil embargo and Iran/Iraq war. At that time, major oil consuming countries worldwide were gripped with fear about the risk of uncertain energy supply and warnings of peak oil. The importance of energy to economic development became a primary concern. These shocks combined with the resulting impacts to global economies stimulated research in energy economics, causing it to emerge as a new branch of financial economic research.

The current energy renaissance is due to technological innovation combined with higher energy prices, which has made it possible to economically produce oil and gas in unconventional formations such as shale and oil sands. This is a major advancement and will help provide the world with energy for economic growth for the foreseeable future. The latest projections of world energy needs by the EIA (Energy Information Administration) for the year 2040 indicate a growth of 54.6 % in energy consumption as compared to 2010. Fossil fuels (oil, natural gas, and coal) are forecast to continue to dominate the energy mix by providing 78.5 % of world energy needs, as compared to 84.1 % in 2010. Renewable energy is expected to grow from 10.7 % in 2010 to 14.5 % by 2040.

The good news is that the world is not running out of fossil fuels anytime soon; peak oil is nowhere in sight. This increasing supply of fossil fuels helps provide time to do the research and development necessary to make the next energy transition for the world. Most experts agree that sustaining even modest economic growth worldwide is going to require massive new investments in energy. While the largest investments will focus on oil and natural gas, it is crucial that more research funds from private firms and governments are devoted to renewable energy sources too.

Overall, more research and innovations in all areas of energy are critically needed to help the world manage energy risk and continue to increase production by promoting all sources.

Moreover, there are other accumulating risks beyond investment that are present which complicate the ability to expand energy production globally from the traditional sources such as oil and natural gas. These risks to energy growth include political instability, the resurgence of resource nationalism, civil unrest, piracy, transit vulnerability, energy subsidies, emissions concerns, extreme weather, and restricted access to resources. These risks present significant challenges to meeting projected worldwide energy demand and must be managed, where possible.

Energy education is crucial to society. Surveys have shown that the public is woefully misinformed about energy. For any society to make informed decisions and recommendations to governments requires an educated voting public. Politicians, regardless of their party affiliation, often take advantage of the public's lack of knowledge and slant information in ways that reinforce misperceptions.

The publication of this book on energy risk at this time is perfect because the information will help educate the public on various aspects of energy including global, geopolitical and market risks. Energy risk is multifaceted and complex. The academic scholars and practitioners who have authored chapters in this book are all experts in their respective areas. The content helps the reader better comprehend this complex topic. For example, the chapters in Part I, Global Risks, cover energy availability and changing dynamics, technology and R&D investment, and energy risk measures. Part II on Geopolitical Risks furthers the understanding of topics such as Central Asia's role in the natural gas revolution, Turkey's role in crude oil and natural gas, and Asian electricity markets. Market Risk is covered in Part III and focuses on a wide variety of topics including financial markets, historical lessons, emissions trading, and renewable energy.

Overall, this book makes valuable contributions to the literature on energy risk. Energy ignorance and illiteracy is completely unacceptable for any society. The world cannot remain passive about this central topic. This book is ideal for energy courses at universities, employee education, and executive education programs in the field of energy. It is a pleasure to read. I encourage universities and practitioners alike to read it and recommend it to others.

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Betty Simkins
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Part III Market Risks

Introduction

1

André Dorsman, Timur Gök, and Mehmet Baha Karan

Abstract

Since the Industrial Revolution, the efficiency with which energy resources are extracted and converted into work has played a prominent role in the accumulation of material wealth. The prominent role of energy resources, in conjunction with their scarcity and their uneven geographic distribution, has had significant repercussions. Collaboration, competition and conflict among nation states for energy resources have created global, geopolitical and market risks. In this volume, academic scholars and practitioners assess these risks from global risk, geopolitical risk and market risk perspectives.

1.1 Chapter 1: Introduction

During the second half of the sixteenth century, fossil fuels first started to become an important source of energy for manufacturers and households in England. But fossil fuels did not begin to have a wide impact on the European and non-European economies until both the consumption and the productivity of energy rose in the first half of the nineteenth century with the advent of the *Age of the Machines*. Machines, such as the newly-invented steam engine, could transform heat into

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mechanical power more efficiently than was previously possible. While the energy efficiency of a human or animal body could not exceed 15–20 %, a thermal machine could reach 35 %.

Unprecedented rates of growth accompanied innovations in transforming energy into work. Between 1820 and 2000, GDP per capita rose 16 times in Western Europe. Over the same period, energy input per head rose about 8 times and efficiency in the use of energy doubled. If one takes into account the contemporaneous 3.8 times increase in population, during this period total energy consumption increased by 26 times.[1]

Higher living standards, massive accumulations of wealth and indelible changes in the environment accompanied the socioeconomic transformations that the century-and-a-half preceding the twenty-first century spawned. The scope and the scale of the transformations that took place have shrouded the dire conditions that preceded this era "in the second half of the eighteenth century and the first two decades of the nineteenth" during a period of "energy crisis and a lowering of living standards" instigated by "[the] rapid growth of the European population from the second half of the seventeenth century onward, on the one hand, and worsening climatic conditions on the other" (Malanima 2006).

Today, as we try to reconcile our insatiable demand for energy with the limits to the resilience of our environment and the finite amount of fossil fuels at our disposal, are the current conditions as dire as they were some centuries ago and is our future as bright as our past? Future historians will answer those questions. In the meantime, as stewards of planet Earth, we will unfold our future as we chart a course through uncertain terrain. The paths that we explore and our destination may be uncertain; that we cannot get "there" without consuming energy is a given. Consequently, the energy that we consume, its availability, its relative price and its environmental footprint will remain as significant risk-factors. In this volume, academic scholars and practitioners assess some of these risk-factors from global, geopolitical and market perspectives.

1.2 Part I: Global Risks

Global energy risks, which stem from the energy cycle, concern the availability of energy; the availability and the efficiency of technology for converting energy into work; and the impact of energy extraction and use on the climate. The authors of the next two chapters address the first two of these questions. The third question, despite its importance, is beyond the scope of this volume.

In Chap. 2, Öğütçü discusses the dynamics and risks of "game-changing" developments in energy markets. The changing dynamics in world energy markets include (1) the growing demand for energy in emerging economies, in general, and

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[1] The historical observations in this paragraph and the one preceding are from Malanima (2010).

China and India, in particular; (2) the "unconventional gas and oil revolution" and the rise to prominence of the U.S. as a supplier of energy; (3) the reluctance of Japan and mature economies in the West to relinquish their privileged status as users of energy; and (4) on a global scale, the gradual depletion of traditional energy resources. Against this backdrop, the author views nuclear power as a "key" source of energy. The author also notes the dilution of Russia's role as a key provider of oil and gas and points out the importance of renewable sources of energy and the diversification of gas suppliers and routes – in particular, via the "Southern corridor" – in meeting Europe's energy needs.

Ordinarily, the changing dynamics and risks in energy markets would generate adaptive strategies in the energy sector. However, in Chap. 3, Jalilvand and Kim show that, as compared with other sectors, the energy sector in the US has not deployed slack resources optimally in terms of investing in developing new technologies and innovations and has lagged behind other sectors in terms of profitability. They suggest that these observations call for more effective regulations and tax policies that will incent greater investment in developing new technologies and innovations in the energy sector.

As compared with strategic adaptation, Chap. 4 is about alternatives for the tactical measurement and management of risks in energy markets. In this book energy risk is the key topic. In Chap. 2 the authors discuss how we can measure energy risk and what the pitfalls are in the interpretations of statistical results.

1.3 Part II: Geopolitical Risks

Energy serves an indispensable function in human affairs. The scarcity of energy as a natural resource and its uneven geographic distribution, have led to and will continue to lead to collaboration, competition and conflict in the allocation of energy resources among nation states. That collaboration, competition and conflict in the allocation of energy resources will not necessarily benefit all nation states is what we call geopolitical risk. The economic importance of energy and the unequal distributions among countries makes energy an important geopolitical factor.

China and India's rise as the newest powers will likely increase geopolitical risks. According to BP (2012), "By 2030 China and India will be the world's largest and 3rd largest economies and energy consumers," and will jointly account "for about 35 % of global population, GDP and energy demand." Given the "pace and scale of development in India and China," the natural gas revolution and, arguably, given the declining influence and power of the United States, what are emergent geopolitical risks at the global and regional levels, such as Central Asia, the Pacific and Europe, and what are the implications of Turkey as a hub for delivery of natural gas to much of Western Europe?

Energy is not only a geopolitical factor for large developing countries, but also for the smaller ones. Turkmenistan, for example, has rich reserves of natural gas. However, it has no access to open seas and to reach international markets Turkmenistan has to use pipelines to China, Iran, and Russia. In Chap. 5, Kolb focuses on Turkmenistan to discuss the sectoral and social impact of the ongoing "natural gas revolution" and analyzes the potential difficulties awaiting energy industries in Turkmenistan and her neighbors.

In Chap. 6, Simpson investigates how economic, financial and political indicators influence electricity markets in South East Asian countries. He finds evidence that electricity markets in China, Thailand and the Philippines are cointegrated, which leads him to conclude the relative efficiency and deregulation of these markets as compared with Malaysia and Hong Kong, which are not cointegrated. He points out that these results may be a helpful starting points in analyzing short- and long-term electricity pricing policies.

In Chap. 7, Arslan-Ayaydin and Khagleeva apply extant models to forecast Turkey's geopolitical market concentration risks by analyzing the "supplier concentration" and the "political stability" of countries that supply crude oil and natural gas to Turkey. Their results underscore that for crude oil imports, Turkey must not only divert to suppliers from other regions, but must also disperse its imports among other oil-exporting countries in the Middle East. The large bias towards Russia in natural gas imports also needs special attention due to the growing portion of natural gas in overall energy sources for Turkey.

The cliché that Turkey is a bridge between continents has only been bolstered by its strategically important location between major gas-producing countries to the East and energy-consuming countries to the West. In Chap. 8, Karan et al. argue that despite reforming its energy markets over the last 15 years, Turkey still needs to be more transparent in liberalizing its internal energy market in its effort to solidify its position as the major European natural gas transit hub.

1.4 Part III: Market Risks

Markets aggregate and convey information, such as prices, and thereby facilitate the allocation of resources in an economy. Equilibrium prices set in competitive, liquid and transparent markets where decision-makers are fully-informed,[2] allow the allocation of resources to their best uses. This is known as the (economic) efficiency of a competitive equilibrium. In markets that allow trades in multiple locations and/or different points in time, the competitiveness, transparency and liquidity – hence, the efficiency – of allocations also calls for the integration of markets within and across borders and over time.

We define market risk as the likelihood of a change in the values of assets and/or liabilities due to an unexpected change in market prices. Competition, transparency and liquidity of markets will not eliminate market risk. For instance, if markets are "imperfect," perhaps due to the lack of competition or the lack of full information by decision-makers, unexpected changes in market prices will lead to changes in the values of assets and/or liabilities.

[2] Without listing additional conditions required, what we have in mind here are "perfect" markets.

Imperfect markets call for regulation, lest they fail. Nevertheless, due to an imperfect understanding or mischaracterization of "perfect" markets, the purpose and the regulation of spot and futures markets, in general, and commodity futures markets (including oil markets), in particular, remain politicized.

In Chap. 9, Hilary Till recounts valuable lessons from the history of U.S. financial markets regarding the conditions that are necessary for commodity futures trading to withstand political pressure. These conditions include increased transparency and better public education to show that these markets function properly and are economically useful.

In Chap. 10, Abudaldah et al. point to the rapid increase in Renewable Energy Source (RES)-generation. Given the existing European transmission systems, the authors discuss how the changed pattern of production locations and timings leads to problems such as transmission bottlenecks and local over- and under-production and how RES-generation affects the day-ahead electricity price in Germany.

In Chap. 11, Gonenc and Yurukova discuss how higher investments in renewable energy will contribute to the growth of the energy sector and thereby to general economic growth. The authors point out the significant role that private external financing plays in addition to governmental energy policies and subsidies. The authors also focus on firm- and country-level factors to analyze the corporate financing and investment activities of renewable energy companies.

On 12 November 2012, the European Union (EU) announced that the aviation sector would be excluded from its Emissions Trading Scheme (ETS) (Lin 2013). In the final chapter, Mooney et al. estimate that the EU-ETS would have cost the aviation sector almost 9 billion euros for the period 2012–2020, which they attributed to a nominal price of 10 euros per tonne of CO_2 emissions. The inclusion of the aviation sector in the EU-ETS had been strongly opposed by many non-EU countries. Although the EU has appeased the critics of the scheme, the carbon footprint of international civil aviation, in particular, and international transport, in general, remains as an issue that must be addressed.

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Part I

Global Risks

Changing Dynamics and Risks in World Energy: The Way Forward

2

Mehmet Öğütçü

Abstract
The energy world has been going through some "game-changing" developments arising from strong demand growth in emerging economies, new supply sources, fuel diversification, technological innovations, "resource nationalism", investment decline, climate change and CO_2 trading, as well as changing geopolitical dynamics. This paper discusses the changing dynamics of the world energy, and emerging new risks in the energy industry and major regions of production, transit and consumption. It also elaborates on the problems of energy "dependence," "independence," and "interdependence" before setting out the future path in the world energy and messages for key stakeholders on key energy dynamics and risks.

2.1 Introduction

As the world struggles to emerge from a global recession and financial crisis, countries are looking for solutions to improve domestic economic performance and put people back to work. The energy sector constitutes a relatively modest share of GDP in most countries, except for those in which oil and gas income loom large. However, the energy sector's impact on the economy is greater than the sum of its parts. Most importantly, almost none of the economy's goods and services could be provided without it. Thus, stable and reasonable energy supply and prices are needed to reignite, sustain and expand economic growth.

The energy debate is increasingly focused on new factors that could prove transformative for global supply and demand, and could alter longstanding assumptions about energy security and geo-economics. The new dynamics in world energy include, *inter alia,* even greater demand growth over the long-term

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emerging outside the OECD area, continued dominance of fossil fuels, new supply sources beyond the Middle East and what was formerly the Soviet Union, strong growth of unconventional fuels (particularly shale oil and gas), price volatility, inadequate investment due to uncertainties and the global economic downturn, conflicts among International Oil Companies (IOC) vs. National Oil Companies (NOC), geopolitical tensions, and heightened concerns with climate change. The revival of nuclear power and new initiatives in renewable energy sources are also expected to play a crucial role in this new order.

In particular, widespread discovery and usage of shale gas, the rise of LNG as a global commodity, and the emergence of an Atlantic energy market in the natural gas industry will considerably change the way energy is consume and how countries' global competitiveness is enhanced or eclipsed.

Trade patterns are changing visibly. For example, a quarter of Iraqi oil, about 2.5 million barrels-a-day (mbd), will be heading for China by 2035. Saudi Arabia is already a major supplier to Beijing. This relationship is part of a shift that is tipping the balance of power in the energy world (Öğütçü 2013). As its oil demand grows and its own reserves -run out, China is becoming increasingly dependent on crude imports (projected to reach 13 mbd by 2030 – more than today's Saudi total production) from the Middle East and Africa (KPMG 2011). That is coinciding with an equally historic process in the western hemisphere – North America's gradual transition towards self-sufficiency in energy and its waning reliance on imported oil (Exxon Mobile 2012).

Price competitiveness, supply security and environmental quality have become major energy industry challenges around the world. However, these goals are not always consistent. The world needs to cut greenhouse gas emissions in half by mid-century to avoid the worst effects of climate change. Thus, the world will need twice as much energy, but with half the emissions (International Energy Agency 2012).

Solutions favourable to the environment, such as photovoltaic solar energy, may have significant effects on price competitiveness. Other solutions favourable to supply security, such as using local coal, may not be favourable to the environment. Energy security and the environment can also come into conflict, such as when the power system relies too heavily on intermittent renewable energy sources. Foreign policy and energy security goals may also often come into head-on confrontation. There is no single ideal solution to achieve these energy policy goals, but at best an optimal mix of solutions.

In the new, energy-centric world, the price and availability of oil and gas will continue to dominate our lives and power will reside in the hands of those who control the global ownership, financing, production, transportation, and marketing of energy.[1]

[1] It will determine when, and for what purposes, we use our cars; how high (or low) we turn our thermostats; when, where, how or even if, we travel; increasingly, what foods we eat (given that the price of producing and distributing many meats and vegetables is profoundly affected by the cost of oil or the allure of growing corn for ethanol); for some of us, where to live; for others, what businesses we engage in; for all of us, when and under what circumstances we go to war or avoid foreign entanglements that could end in war. See "The end of the world as we know it, "Michael Klare, August 2008, http://www.redpepper.org.uk/The-end-of-the-world-as-we-know-it/

The world of 2030 will be radically transformed from our world today. By 2030, no country – whether the US, China, or any other large country – will be a hegemonic power. The empowerment of individuals and the diffusion of power among states, and from states to informal networks will have a dramatic impact, possibly halting the historic rise of the West since 1750, and restoring Asia's weight in the global economy (U.S. National Intelligence Council 2012).

As globalization lifts millions out of poverty and the demand for energy worldwide continues to grow, the world risks ending up with a volatile, "beggar thy neighbour" style of competition among countries to control sources of supply, especially in the developing world, giving rise to more conflict and confrontation than co-operation and collaboration.

Two key *megatrends* will shape our world out to 2030: demographic patterns, especially rapid aging; and growing resource demands which, in the cases of food, energy and water, might lead to scarcities. These trends, which are virtually certain, exist today, but during the next 15–20 years they will gain much greater momentum. These changes will not occur without serious risks, particularly above-the-ground risks, that will threaten the energy sector seriously in today's interconnected world (U.S. National Intelligence Council 2012).

This is not the first time that the energy sector has faced uncertainty – recall the oil shocks of the 1970s and 1980s. Nonetheless, uncertainty is at its height now. Uncertainties are particularly dangerous in a sector where investments are long-lived and take a long lead-time to pay off. Considerable uncertainty also extends to global gas markets.

Overall, severe income disparity, chronic fiscal imbalances, geopolitical tensions, technology hazards and natural resources security concerns are among the top risks facing business and government leaders over the next decades. Deeper problems could be brewing in much of the developed world, where overextended governments face political, economic and demographic pressures to reduce social protections, pensions and other commitments.[2]

The aim of the paper is to elaborate on the "game-changing" dynamics in world energy and how it will create new risks in the energy industry, and to draw conclusions for policy- and decision-makers in government and business to mitigate these risks.

The paper is divided into eight sections. In Sect. 2.2, changing dynamics in world energy are explained, then the new developments in natural gas sector and the role of nuclear energy are discussed in Sects. 2.3 and 2.4. Current positions of Russia and Europe are evaluated in Sects. 2.5 and 2.6. Section 2.7 discusses the future of the Southern Corridor and Sect. 2.8 concludes the paper.

[2] Further economic shocks, social upheaval and energy shortages could roll back the progress globalization has brought over the past few decades as the world's institutions are ill-equipped to cope with today's rapidly evolving risks that require effective risk mitigation and management.

2.2 Changing Dynamics in World Energy

The fundamental transformation currently underway in the global energy scene will not only change the rules of the game; it will also change the game itself, and its players. Four great trends are likely to define the new energy landscape (U.S. National Intelligence Council 2012):

- The rise of new economic dynamos like China and India, with voracious appetites for energy and other raw materials;
- The emergence of the US as the next energy superpower in oil and gas due to an "unconventional gas/oil revolution";
- The reluctance of the mature industrial powers, led by the US, Europe, and Japan, to abandon their privileged status atop the resource-consumption pyramid; and
- The gradual depletion of many of the world's vital resources.

About 1.4 billion people worldwide still lack access to energy. Projections, be they from IEA, EIA or Shell, Exxon, BP, indicate that global energy demand will nearly double in the first half of this century. According to the U.S. Department of Energy, there already has been a 47 % rise in the past 20 years alone, and this is expected to grow by 35–46 % between 2010 and 2035. Most of that growth will come from the new engines of the world economy – China, India and partly the Middle East, where the consuming class is growing rapidly (U.S. National Intelligence Council 2012).

The world will be home to about nine billion people in 2050, up from 6.8 billion today, fuelling further growth in demand for energy. At the same time, increasing wealth is improving living standards and raising millions of people out of poverty in developing regions. As incomes grow and living standards improve, people are buying their first cars, air conditioners or refrigerators – which need massive amounts of energy. Worldwide, the number of cars and trucks on the roads is expected to rise from around 900 million today to around two billion by the mid-century (The Independent 2010).

The relative distribution of power is changing with the erosion of America's margin of superiority in economic, military, and 'soft power' terms. Few financial concepts have caught on as quickly as "BRICs," a term coined by a Goldman Sachs economist, which stands for Brazil, Russia, India and China, the "Big Four" fastest-growing economies in the world today. By dint of their sheer size and population – and their collective decision to embrace their own particular brand of capitalism – BRICs are seen as the economic future of the world. Together, the BRICs encompass more than 25 % of the world's land mass and 40 % of the world's population (Press Release, United Nations 2009)[3].

[3] China and India will become the dominant global suppliers of manufactured goods and services. Economic aspirations in Brasilia, Moscow, New Delhi and Beijing are inextricably linked to the strength of their national energy sectors.

As the economies of the BRIC nations continue to grow, their demand for energy will rise sharply. According to data from the U.S. Energy Information Administration, by 2025 the BRICs will account for nearly 38 % of global primary energy demand, up from 27 % in 2005 (Ebinger et al. 2012). Hence, unless massive investments and new technologies are mobilized in the next few decades, energy supplies are likely to get tighter for all economies (BizShift-Trends 2011)...

An increase of this sort would not be a matter of deep anxiety if the world's primary energy suppliers were capable of producing the needed additional fuels. Instead, we face a frightening reality: a marked slowdown in the expansion of global energy supplies just as demand rises precipitously. These supplies are not exactly disappearing – though that will occur sooner or later – but they are not growing fast enough to satisfy soaring global demand (Dejevsky 2012).

While demand is growing, new suppliers are appearing on the horizon. Of particular importance is the resurgence of US oil and gas production, particularly through the unlocking of new reserves of oil and gas found in shale rock. One should also take into account the Arctic region, Brazil, Australia, Central Asia, the east Mediterranean and East Africa as additional suppliers.

The emergence of powerful new energy consumers- global energy supply increases only gradually, is creating an energy-deficit world, characterized by fierce international competition for dwindling stocks of oil, natural gas, coal and uranium, as well as by a tidal shift in power and wealth to energy-surplus states like Russia, Saudi Arabia and Venezuela. As the demand for energy accelerates, an energy revolution is needed on the demand side as well, where big changes should be effected relatively quickly to improve energy efficiency (The Independent 2013).

Geopolitics has gained the upper-hand once again in world energy. The root-causes for most geopolitical tensions are the scarcity of resources that fuel competition among nations for a bigger pie, particularly in energy, water and food. Throughout history, major shifts in power have normally been accompanied by violence – in some cases, protracted violent upheavals. Either states at the pinnacle of power have struggled to prevent the loss of their privileged status, or challengers have fought to topple those at the top of the heap.

Disputes in the Caspian basin, the South China Sea, the Arctic, the Strait of Hormuz, and the Eastern Mediterranean are largely instigated by energy resources and how they should be developed, extracted, distributed and transported among bordering nations. The most explosive one seems to be the South China Sea. China is already the world's largest energy consumer and imports a growing share of its oil and gas, so the question of how much oil and gas is under the South China Sea is hardly an idle one. Beijing is keen to make the country more self-sufficient in energy and to this end has encouraged domestic sources of power, including hydropower, nuclear energy, wind and solar energy (Solar Energy 2012).

Aside from geopolitical disputes, the economics of extraction are also set to play a big role in the development of disputed areas. Some countries have a strong urge not to procure energy for their own use, but to dominate the flow of energy to others. In particular, Moscow seeks a monopoly on the transportation of Central Asian/Caspian gas to Europe via Gazprom's vast pipeline network. It also wants to tap into Iran's mammoth gas fields, further cementing Russia's control over the trade in natural gas (Kilyakov 2012).

The danger, of course, is that such endeavors, multiplied over time, will provoke regional arms races, exacerbate regional tensions and increase the danger of great-power involvement in any local conflicts that erupt, as they currently do.

2.3 Natural Gas as a Game-Changer

The share of natural gas among sources of primary energy is rising faster than that of oil and coal. At the same time, the gas industry is undergoing immense changes as new technologies, demand and supply patterns create new market forces.

In 2011, after the Fukushima nuclear accident, the International Energy Agency heralded the arrival of a "golden age" of gas in the period until 2035 due to enormous economic growth in China combined with significant gas consumption, a low share of nuclear energy in the generation of electricity, an increase in the use of gas in the transportation sector, and a boom in unconventional gas production and subsequently lower prices. Electricity from renewable resources still requires natural gas as a back-up energy source because an uninterrupted supply of renewable energy is not available – at least until technology enabling the high-efficiency storage of electricity is discovered and commercialized (Öğütçü and Öğütçü 2010).

Unconventional gas is becoming a real game changer in the US gas market. The widespread adoption of techniques such as hydraulic fracturing and horizontal drilling, have made those reserves much more accessible, and, in the case of natural gas, has resulted in a glut that has sent prices plunging. The "shale gale" sweeping across North America the past few years has more than doubled the size of discovered natural gas resources in North America – enough to satisfy more than 100 years of consumption at current rates, according to a major new analysis of the leading unconventional gas plays in North America by IHS Cambridge Energy Research Associates (Williams 2012).

In 2010, 12 billion cubic meters (bcm) of LNG was imported into the US. Before this unconventional gas revolution, this number was expected to reach 140 bcm by 2020. Now, the US is set to become a major natural gas exporter, transforming the global gas market. The price of gas sold by Henry Hub in the U.S. dropped in 2012 to a level of $2 per million metric British thermal unit (MMBtu), its lowest level in the past decade, while the European average spot price and oil-indexed price have fluctuated between $8 and $10, and the Japanese averaged around $17 (Foss 2011).

If the Henry Hub price remains near $3, LNG exports of domestic production look very competitive at anticipated prices in Europe. If the Henry Hub price is raised and a higher price event or set of events happens, such that a $10 spike is tenable, then exports look out of the question.[4] A future price level that could

[4] The exception could be Asia with the most logical route being from western Canada (or Alaska, if backers of an "all Alaska" solution for monetizing North Slope natural gas with a pipeline to Cooke Inlet won out).

accommodate a $10 price spike also could be more attractive to LNG imports (Foss 2011).

The US success story has inspired many other countries, including Argentina, China, Poland, South Africa and the UK, to develop their own reserves. Shale development in China, home to the world's largest shale deposits, has been slower than predicted by the government. China may produce 6.5 bcm of shale gas annually by 2015 and has set a target of 60–100 bcm of production annually by 2020, according to China's National Development and Reform Commission (Enoe et al. 2012).

However, as yet, no country other than the US has what could be termed a shale gas industry – gas production from tight oil and shale plays is still negligible outside the US. Most production increases will only come after 2020, as countries need time to develop the commercial unconventional gas sector due to various geological, logistical and regulatory challenges. The countries where shale gas is presumed to exist in the EU are Germany, Poland, Sweden, France, Austria, Hungary and the UK. Warsaw is harbouring major ambitions to develop shale gas, the switch towards which is like "the twenty-first century's gold rush" (Oswald et al. 2012).

But, shale gas cannot yet be seen as a game changer in Europe as it is in the US, where roughly 50 % of the country's needs are met by developing unconventional gas. To illustrate the possible impact of developing shale gas in Europe, the U.S. Geological Survey pointed out that in an area the size of the Benelux countries, there would have to be up to 6,000 wells, an impact that would probably attract environmental opposition. The reason for such concentration is that unlike natural gas, unconventional gas needs a high density of wells, including horizontal wells (Oswald et al. 2012).

Another development that has transformed and continues to transform the landscape of the natural gas industry is the advent of Liquefied Natural Gas (LNG). This mode of transport allows gas-exporting countries to ship their gas over long distances and releases them from the traditional dependence issues associated with pipelines. Pipelines are expensive and, once built, tie producers and consumers together indefinitely, while LNG allows both exporting and importing countries to escape this form of captivity. Understandably, this has both commercial as well as geopolitical consequences.

Between now and through 2015, several Southeast Asian countries will emerge as new LNG importers and demand in existing markets will increase steadily. On the supply side, however, only a small number of new projects are coming on line; these are the Pluto LNG project in West Australia, the Angolan LNG project, and the Algerian LNG project. Consequently, the world LNG market will likely tighten up. However, the final impact remains uncertain: the prevailing European economic crisis may keep demand sluggish or prolonged shutdowns of nuclear power plants in Japan may keep demand for LNG high (World Economic Forum 2011).

In 2011, final investment decisions were made for several LNG plants that will go on stream in the Pacific basin in 2015 or later. These projects, if commissioned without delay, would contribute to stabilize the LNG market in the long-run.[5] In addition, new prospective supply sources are coming up in East African countries like Mozambique. At the same time, LNG exports from North America are emerging rapidly as a next-generation supply source. The Sabine Pass project, which has recently fixed sales agreements for 16 million tonnes, uses low-cost gas brought about by the shale gas revolution.[6]

Despite the rise of LNG, pipelines are still the backbone of the gas industry. Transport by pipeline is not as flexible as by LNG tanker, but is often the cheapest method, depending on the geographical location.[7] Coal, oil and gas, particularly natural gas, will continue to play an important role,. Abundant, affordable and acceptable – gas is a triple-A source of energy. It is cleaner than coal; gas-fired generation is relatively quick and inexpensive to build; and the shale revolution in North America has raised hopes that gas is abundant in geological formations the world over (Bettinger et al. 2010).

2.4 Nuclear 'Key' to the World's Energy Future

The holy grail of alternative energy sources is nuclear fusion, where power is generated by fusing atomic nuclei together in a reaction that releases immense amounts of energy. Fusion is the same reaction powering the Sun. It has the advantage over conventional nuclear fission power in that it is clean and virtually waste-free – but it only seems to work at the intensely high temperatures found in the Sun, a problem for a reactor on Earth.

Nuclear power stations have proven to provide a steady "base load" whether the wind is blowing or the sun is shining, and of course, they do not require fossil fuels – although there is the question about continued supplies of uranium and what to do with the nuclear waste.

Despite Japan's Fukushima accident following the tsunami in March 2011, the latest projections by the International Atomic Energy Agency show that the global use of nuclear power will grow significantly in the coming decades. Power produced from nuclear fission is now a mature technology that provides about 16 % of the world's electricity and almost a third of that in the EU. Many emerging market

[5] The overall LNG production capacity of Australia – including the Ichthys project, which was given the green light in early 2012 – will exceed 80 million tonnes a year around 2018, making the country the largest LNG exporter in the world. The Ichthys LNG project, to be operated by INPEX with its primary export destination being Japan, is considered virtually a *Japan-made* project. As some of the Japanese buyers have formed a consortium for joint purchasing, it could provide a model case for structuring future purchasing strategies.

[6] Its cost is estimated to be about 30–40 % lower than the LNG procurement cost of Japan. Other LNG projects coming up in North America, if materialized as proposed, could have a sizeable impact on the LNG pricing system in the Asia-Pacific region.

[7] The development of a number of new pipeline projects in Europe, starting with Nord Stream, is helping to bolster transmission capacity and security of supply. Recent agreement for new pipelines in emerging markets, particularly between Russia and China, underline the importance of natural gas in the twenty-first century energy landscape.

governments have committed to a fresh round of building nuclear fission power stations, despite opposition from environmentalists and those concerned about nuclear proliferation. Over 30 countries benefit substantially from nuclear energy. In addition to the 400 or so nuclear power plants around the world, many more are to be built over the next 30 years (Trajonowska 2012).

Nuclear power plants are being given lifetime-extensions in Spain and in the UK and new ones are not only being considered or actively planned in Slovakia, Hungary, the Czech Republic, Bulgaria, Romania, Poland and Lithuania, but in the UK too. And they are under construction in France and Finland. In other parts of the world, new nuclear power projects are more visible still. The dynamic economic growth of Asia has seen the most rapid expansion of nuclear programmes, with China, India and Korea basing their development to a very large extent on nuclear energy, just as Japan did 40 years ago. Japan also intends to restart its nuclear plants after the post-Fukushima safety review (The World Nuclear Industry Satus Report 2012).

The same even applies to oil and gas producing states, like the United Arab Emirates and Saudi Arabia. Although its ambitious goals are still only on paper, the Emirates have already begun to earmark nuclear investment. Even in the US, despite the shale-gas rush, licenses have just been approved for four new reactors. Nuclear power development is making progress in Russia too.

Every time there is an accident, proponents of nuclear power point out that risks are also associated with other forms of energy. Coal mining implies mining disasters, and the pollution from coal combustion results in some ten thousand premature deaths in many countries including China, USA and Russia each year. Oil rigs explode, sometimes spectacularly, and so, on occasion, do natural gas pipelines. Moreover, burning any kind of fossil fuel produces carbon-dioxide emissions, which, in addition to changing the world's climate, alters the chemistry of the oceans.

Among those who argue most passionately for nuclear power these days are some environmentalists, who see the uncertain threat that it presents as preferable to the certain harm of climate change. An objective comparison might indeed suggest that a well-designed and vigorously regulated nuclear power plant poses less danger than, say, a coal-fired plant of comparable size.

For countries such as Japan, the contribution of nuclear energy to enhancing energy security is not small in view of its low cost, large scale, and high energy density. To date, Japan has been working on energy security by concentrating on ensuring supply of oil and stabilizing its price. However, following the Great East Japan Earthquake, unexpected problems have surfaced such as shutdowns of nuclear power plants and the huge Asian premium on LNG prices. The market mechanism alone is insufficient to guarantee energy security and Japan needs to mobilize other measures including subsidies and grants on R&D, resource diplomacy, and safety regulations (Kolbert 2011).

This made it necessary to rebuild Japanese energy policy carefully by re-examining what measures are practicable, feasible and effective. Nuclear option is now diminishing and can no longer be considered as the single central pillar, while renewable energy could not be a leading source. Other feasible options include construction of domestic trunk gas pipelines, as well as piped natural gas imports from Russia, though substantial reform of the Japanese gas and electricity industries is a prerequisite "bundle" wholesalers and independent gas buyers.[8]

Nuclear energy is no silver bullet for resolving all of the world's energy problems. But it is a crucial part of the global solution of a sustainable and diversified energy mix. And greater diversification of electricity generation technologies means greater security of supply. Hence, nuclear energy must be seen as essential to a common solution, and not as a rival to other technologies. It has already contributed to the development of other, mainly renewable, energy sources.[9]

2.5 Is Russia on the Losing End?

Russia holds the world's largest proven reserves of natural gas and continually alternates with Saudi Arabia as the top oil producer. The country supplies a third of Europe's oil and natural gas and is starting to export more to the energy-hungry East Asian markets. The energy sector is far more than a commercial asset for Moscow; it has been one of the pillars of Russia's stabilization and increasing strength for more than a century.

The future of Russia's ability to remain a global energy supplier and the strength that the Kremlin derives from the Russian energy sector are increasingly in question. After a decade of robust energy exports and revenues, Russia is cutting natural gas prices to Europe while revenue projections for Gazprom are declining starting this year. Gas is available on a spot basis today in Europe at prices lower than the oil-indexed prices of long-term contracts signed with Russia (Kilyakov 2012).[10]

With the US on its way to replacing Russia as the world's top gas-producing superpower by 2015 – and coming close to Saudi Arabia as leading oil producer by 2017 – Russia seems to be on the side of those who will suffer most from the game-change in energy.

Currently, energy revenues make up half of the Russian government's budget. This capital influx was and continues to be instrumental in helping Russia build the military and industrial basis needed to maintain its status as a regional – if not

[8] In this regard, particular attention will need to be paid to development of Japan-Russia relations in the era of Putin's new administration. See Asian premium on gas strikes LNG importing countries, http://eneken.ieej.or.jp/en/jeb/1203.pdf

[9] In Germany, nuclear operators pay a special "renewable energy" tax, and in Poland legal arrangements designed for the development of nuclear power plants are used to improve the electrical grid so as to connect renewable sources to it.

[10] None of the major energy industries – oil, gas or power – developed on the basis of a spot market alone. The search for balance between competition and security is central to an understanding of the role of spot markets and long- term contracts in the global gas trade. See http://www3.weforum.org/docs/WEF_EN_EnergyVision_NewGasEra_2011.pdf

global – power. However, as the Russian governments became dependent on energy, the revenues also became a large vulnerability (Goodrich et al. 2013).

The energy sector also contributes to Russia's ability to expand its influence to its immediate neighbors. Moscow's use of energy as leverage in the buffer states differs from country to country and ranges from controlling regional energy production (as it previously did in the Azerbaijani and Kazakh oil fields) to subsidizing cheap energy supplies to some countries and controlling the energy transport infrastructure. Russia has used similar strategies to shape relationships beyond the former Soviet states (Gorenburg 2013).

As things stand, Gazprom's unparalleled prosperity and dominant market position in Europe have been seriously upset by the "shale energy revolution" and emergence of new suppliers/competitors both within Russia (i.e., Novatek and Rosneft) and outside. Domestic competitors challenge Gazprom's dominance. The share of gas supplied by independent producers has increased to 25 %. Novatek (Russia's largest independent producer of natural gas) has put an end to Gazprom's monopoly on gas exports by signing a 10-year contract with Germany's EnBW Group worth 6 billion euros. Rosneft too is a significant new power to reckon with for Gazprom. Russia has also lost a great deal of its influence in Central Asia or the "near-abroad" to China (Kilyakov 2012).

A set of EU-wide policies, including the Third Energy Package, have started to give EU member nations the political and legal tools to mitigate Gazprom's dominance in their respective natural gas supply chains. This common framework also allows European nations to present a more unified front in challenging certain business practices they believe are monopolistic – the latest example being the EU Commission's probe into Gazprom's pricing strategy in Central Europe.[11]

New gas production set to begin in Azerbaijan, Turkmenistan, Australia, Tanzania, and East Mediterranean may further aggravate the gas glut problem for Gazprom, driving the prices downward and changing the geopolitical dynamics.

The Kremlin appears keenly aware of the challenges that Russia will face in the next two decades as another energy cycle draws to an end. Unlike Brezhnev and Gorbachev, Putin has proven capable of enacting effective policy and strategy changes in the Russian energy sphere. While Russia's dependence on high oil prices continues to worry Moscow, Putin has so far managed to respond proactively to the other external shifts in energy consumption and production patterns – particularly those affecting the European natural gas market. However, the long-term sustainability of the Russian model remains doubtful.

[11] This, coupled with the EU-funded efforts to physically interconnect the natural gas grids of EU members in Central Europe, has made it increasingly difficult for Russia to use natural gas pricing as a foreign policy tool. This is a major change in the way Moscow has dealt with the region for the past decade, when it rewarded closer ties with Russia with low gas prices (as with Belarus) and increased rates for those who defied it (the Baltics).

2.6 Europe at a Crossroad

Europe appears to be missing out on the natural gas boom that is transforming energy use in the US and Asia. A European boom in shale gas extraction remains unlikely in the near future due to low levels of support among politicians and the public. Bulgaria and France have already banned exploratory drilling that employs controversial hydraulic fracturing technology. Similarly perplexing information is also coming from Poland, an advocate of shale gas in Europe, where ExxonMobil recently declared an end to exploratory work due to insufficient commercial quantities.

European utilities' preference for burning coal to generate electricity is pushing up carbon emissions even though the region has invested twice as much in renewable energy as the US since 2004. In Europe, gas costs three times as much as in the US, cutting competitiveness for industrial users such as Germany's BASF, the world's largest chemical maker, which intends to relocate some of its facilities to the US (Öğütçü 2013).

Gas is becoming too expensive a fuel for Europe. More than half of Europe's supply of fuel is bought through long-term contracts linked to the price of oil, and that will remain the case until 2014 (Öğütçü 2013).[12] Even after a wave of renegotiations, most prices for gas from Gazprom, which meets about a third of the EU's needs through contracts tied to oil, were reduced no more than 10 %.[13] Disputes remain with RWE, Germany's second-largest utility, and the Polish gas company PGNiG (Badida 2013).

All EU member states are free to shape their own domestic energy mix, so decisions concerning the share of renewables in energy generation need to take national circumstances into account. Decisions on increasing the share of renewables obviously have to fit into the overall infrastructure development strategy. Both domestic and cross-border grids and energy storage arrangements need to be strengthened so they are able to absorb projected levels of unstable electric power.

Increasing the share of renewables looks set to be an important element in the strengthening of Europe's energy independence, in line with other sources like nuclear, coal and gas. And it has to be borne in mind that, if not correctly handled, boosting renewables could yet result in increased dependence on imported technologies and equipment. Over-optimistic assumptions about renewables can place a significant financial burden on the economies of many EU countries by decreasing their competitiveness, and causing a drastic increase in electricity prices unless corresponding actions are taken elsewhere in the world.

[12] Note that Brent crude has climbed 72 % over the past 4 years.

[13] The planned construction of LNG export terminals in Australia and the US in 2015 should lead to an increase in the security of supplies to Europe but the overall positive effect on European prices is questionable as LNG is more expensive than pipeline gas. LNG prices must fall to $9–$11 per MMBtu if it is to be affordable for buyers in the EU, India and China.

The importance of coal to future power engineering in Europe must be stressed. Coal is set to remain a significant fuel in the EU for decades to come, not just in the energy sector but for industries like steel or pulp and paper. But the rising costs of CO_2 will at the same time create a major threat to the competitiveness of these key industries.

Forced "European" solutions that do not consider the domestic situations of all are not in line with the democratic principles of the EU. Unless we take serious account of global circumstances, such solutions could even halt the economic growth of some member states and eventually the EU as a whole. Without a sustainable energy mix that includes different forms of energy, the European economy will be less competitive, industry will move abroad and jobs will inevitably be lost.

2.7 The Future of the Southern Corridor

The Southern Corridor is important for Europe in terms of diversifying its gas suppliers and routes – particularly away from Russia. Natural gas imports are likely to occupy an increasingly central role in Europe's energy portfolio, necessitating multiple alternatives such as a new Southern Corridor. Europe's reliance on natural gas imports has been exacerbated by a steep decline in natural gas production within Europe, Germany's decision to phase out nuclear power (France, too, is considering a scaling back of nuclear energy), and opposition to shale gas in several EU countries.

Development of a Southern Corridor to link the Caspian to Europe with oil and natural gas pipelines was an early element of a western strategy to reduce dependence on Russia. The first stage was achieved with the completion of the Baku-Tbilisi-Ceyhan oil pipeline from Azerbaijan to a Turkish Mediterranean port and the South Caucasus Gas Pipeline from Azerbaijan to Turkey. The next stage of Southern Corridor development is to use expanded production of natural gas in Azerbaijan as a supply anchor. This stage envisions the expansion of the South Caucasus Pipeline. There is also a prospect of additional gas from Turkmenistan and Iraq to further supply the Southern Corridor.

From the US perspective, this Corridor would further isolate Iran, assist in cultivating partners in the Caucasus and Central Asia and bolster their sovereign independence, and perhaps most importantly, curtail Russia's energy leverage over European NATO allies.[14] Among EU countries, Austria, Bulgaria, the Czech Republic, Estonia, Finland, Latvia, Lithuania, Poland, and Slovakia all depend on Russia for over 60 % of their gas imports; EU aspirants such as Moldova, Turkey,

[14] "Energy and Security from the Caspian to Europe," a minority staff report prepared for the use of the Committee on Foreign Relations, United States Senate, Washington: 2012, http://www.gpo.gov/fdsys/

and Ukraine rely on Russia for over 65 % of their imports (World Economic Forum 2011).

Some critics may argue that the Southern Corridor should be a lower priority: US shale gas and global LNG trade is producing more market liquidity, thus tending to lower prices and improve Europe's negotiating position with Russia. Russia's Gazprom has been forced to change its domestic strategy, including abandoning its flagship Stockman project in the Arctic, and it has had to contend with plummeting market value and a new EU antitrust investigation. These trends may or may not last, but their existence today gives an unprecedented opportunity to advance broad natural gas diversification and break Russia's control over European gas markets (World Economic Council 2013).

Turkey's rapidly growing domestic energy demand has been a central dynamic of the Southern Corridor. In particular, its willingness to allow transit of significant amounts of natural gas to Europe, even when its own domestic market could easily consume the gas, has bolstered the prospects for the Southern Corridor. Azerbaijan is the pivotal supplier for the Southern Corridor and is positioned to be a long-term transit hub for potential trans-Caspian supplies from Turkmenistan and Kazakhstan. For the past two decades, Azerbaijan's leadership has made a strategic decision to use new pipelines to forge closer ties with the West (Öğütçü 2013).

Beyond Shah Deniz II gas, securing additional supplies for the Southern Corridor is crucial. Turkmenistan's conventional natural gas supply, the world's fourth largest, has high potential for being joined to the Southern Corridor by constructing a Trans-Caspian Pipeline from Turkmenistan to Azerbaijan's energy infrastructure.

However, a combination of inscrutable leadership, geopolitical pressure by Russia, and an investment climate unfriendly to energy majors has hampered progress, and the window for Turkmenistan's participation in the Southern Corridor may be closing. Most critically, the President of Turkmenistan must be willing to assert his nation's political independence from Russia by executing the necessary reforms that will make increased production and trans-Caspian transit a reality.

Conclusion and Key Messages

As the preceding sections clearly indicate, world energy risks multiply and become increasingly difficult to mitigate as a result of complex issues at hand, resource constraints and a multitude of new actors in search of a place in the system.

The global energy sector will transform through 2050 and will become increasingly complex and risky. The pressure on decision makers in both the public and private sectors will increase and, in particular, the demands on those responsible for energy policy will intensify. Policies formulated today and the resulting actions and behaviours of citizens will have effects and consequences far into the future (World Energy Council 2013).

Not so long ago the global energy map looked simple and – for the Western world – somewhat intimidating. There were the Gulf States and there were the Russians exporting fossil fuels who could dictate their terms. There were the resource-hungry Chinese preparing to plunder Africa for raw materials; there was Norway showing us all how a small petro-state should be run; and there were the environmentalists and climate change people (not always the same) whose chief preoccupations were reducing carbon emissions and promoting renewables. Much policy was determined by fear of an energy shortage that always lurked just below the surface (Öğütçü and Öğütçü 2010).

The economics of energy internationally are changing beyond recognition, and the political shifts and risks will not be far behind.

Major shifts of power between states, not to mention regions, occur infrequently and are rarely peaceful. In the early twentieth century, the imperial order and the aspiring states of Germany and Japan failed to adjust to each other. This conflict resulted in the devastation of large parts of the globe. Today, the transformation of the international system will be even bigger and the rising new powers are nationalistic, seeking redress of past grievances, and will want to claim their place under the sun.

The uneven distribution of energy resources among countries is a constant source of friction, giving rise to significant vulnerabilities such as the ones that occur in the Strait of Hormuz, the Malacca Straits, the East China Sea, the Caspian Sea, the Kurdistan Regional Government versus Baghdad and the east Mediterranean, as well as the domestic instabilities triggered by the Arab Spring, the Nigerian labor strikes, the attacks in Algeria, the breach of contract sanctity in Kazakhstan and the ongoing Iraqi unrest. They all vividly illustrate how above-the-ground factors could inhibit hydrocarbon development (Hook 2012).

The signs indicate more confrontation than collaboration, particularly over resources as the gap between supply and demand widens. Additionally, most resource-holders want to change the balance of interests with international extraction companies in order to maximize their gains through so-called "resource nationalism."

It is not only resource-rich countries that are firing the shots in the new energy game. Industrialized importing countries are also resorting to what is called "economic patriotism" to protect their strategic sectors. The expansion of government-owned companies from hydrocarbon-importing developing countries such as China and India into oil and gas exploration activities on a global scale is gaining added momentum.

The most spectacular actual transformation so far is the impact in the U.S., where the exploitation of shale gas and oil has already reduced domestic energy prices by as much as half and could make the U.S. a net exporter. This is a happy outcome not just for American consumers, but for manufacturers, too. As production costs in China and elsewhere rise, this could lead to the repatriation of some industry. But the trend has already prompted grumbling from Europeans and, without following the U.S. example, the EU may find itself uncompetitive in the global market.

There could be a knock-on effect on the Gulf and the Middle East. Saudi Arabia has recently reduced its oil production, partly in response to the drop in U.S. demand. It finds itself in a similar position to Russia – as dependent on Western demand as the West is dependent on supply – but with an economy even more reliant on energy exports, a less-educated population, and the winds of political change blowing all around.

Western countries are producing less and less of their own energy, and are, therefore, having to import more and more. This is having a massive impact on the transfer of wealth. What we know is that these massively increased energy revenues not only mean more economic power for the oil producers, but also, of course, increasing political power and influence in shaping the new global security order.

The coercive manipulation of energy supplies, competition over energy sources, the tendency of energy producing countries to political instability, attacks on supply infrastructure, competition for market dominance, accidents, and natural disasters are all adding significant risks to global energy security. Increased competition over energy resources may also lead to the formation of security compacts to enable an equitable distribution of oil and gas between major powers.

The evolution of energy economics in the U.S. casts doubt on the sustainability of Europe's investment in renewables. Germany leads the field here, with its renunciation of nuclear energy – a political decision made when the Fukushima disaster in Japan coincided with a sensitive regional election – and pledges to draw 50 % of its energy from renewables by 2050. But the temptation for even the most green-minded European governments to retreat from the development of wind and wave power could become hard to resist if gas and oil can suddenly be produced or bought much more cheaply.

In this new stage of energy competition, the advantages long enjoyed by Western energy majors has been eroded by vigorous, state-backed upstarts from the developing world. The rising economic dynamos will have to compete with the mature economic powers for access to remaining untapped reserves of exportable energy – in many cases, bought up long ago by the private energy firms of the mature powers like Exxon Mobil, Chevron, BP, Total of France and Royal Dutch Shell. Of necessity, the new contenders have developed a potent strategy for competing with the Western "majors": they've created state-owned companies of their own and fashioned strategic alliances with the national oil companies that now control oil and gas reserves in many of the major energy-producing nations.[15]

Both unilaterally and through the EU, European countries began developing strategies that would allow them to mitigate not only Europe's vulnerability to disputes between Moscow and intermediary transit states, but also its general dependence on energy from Russia. The accelerated development of new

[15] China's Sinopec, for example, has established a strategic alliance with Saudi Aramco to explore for natural gas in Saudi Arabia and market Saudi crude oil in China. Likewise, CNPC will collaborate with Gazprom, to build pipelines and deliver Russian gas to China. Several of these state-owned firms, including CNPC and India's Oil and Natural Gas Corporation, are now set to collaborate with Petroleos de Venezuela SA in developing the extra-heavy crude of the Orinoco belt once controlled by Chevron.

and updated LNG import facilities is one such effort. This will give certain countries – most notably, Lithuania and Poland – the ability to import natural gas from suppliers around the globe and bypass Russia's traditional lever: physical connectivity.

This is particularly significant in light of the accelerated development of several unconventional natural gas plays in the world, particularly the shale reserves in the U.S. The development of a pipeline project that would bring non-Russian Caspian natural gas to the European market is another attempt – albeit less successful so far – to decrease European dependence on Russian natural gas.

The future is far from certain and the rate of technology change in both the supply and the demand sides of the energy sector is increasing. Government policies must therefore be quite clear in their intent and less prescriptive in terms of the means, permitting those responsible for implementation the requisite degree of freedom to apply the best technology solutions and systems to meet the objectives. Countries or corporations where policy explicitly favours or restricts certain technology options may find it difficult to keep up with the evolution of the global energy sector.

Industry leaders have to ensure that corporate policy, investment criteria, and business practices are all geared to deliver the goods and services that support the government's policy intent. Policy initiatives are not only necessary at the national level but also must consistently cascade down to sub-national and local levels. These initiatives have to pay particular attention to the development of transportation systems, planning towns and cities, modernisation of communication systems, and work practices.

Energy sustainability is a golden thread that runs through the long-term survival of economies and indeed society. Clear and consistent policies that respect the environment while providing the energy necessary are required. An integrated view across the many facets of government is necessary. In fact, it is difficult to identify any one facet of government that does not contribute to and at the same time depends on a sustainable supply of energy.

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Biography

Mehmet Öğütçü has more than 30 years of a successful track-record in government, diplomacy, international organisations (NATO, IEA, OECD), banking, and the energy business. He currently is chairman of Global Resources Corporation, a senior advisor to BG Group, chairman of Invensys Plc. Advisory Board, and an independent non-executive director on the boards of Genel Energy Plc. and Yasar Group of Companies. Öğütçü previously served as the head of OECD's Global Forum on International Investment and Regional Outreach programmes, principal administrator for Asia-Pacific and Latin America at the International Energy Agency, Turkish diplomat in Ankara, Beijing, Brussels and Paris, inspector at Is Bankasi, NATO Research Fellow, EU's Jean Monnet Fellow, and advisor to the late Prime Minister Turgut Ozal. He can be contacted at ogutcum@yahoo.co.uk

Slack Resources, Innovation and Growth: Evidence from the US Energy Sector

3

Abol Jalilvand and Sung Min Kim

Abstract

Recent studies show that the US energy sector's investment (particularly by the private sector) in technology development and innovation has been declining, lagging behind other sectors in the economy, and mainly focused on the fossil fuel-based areas related to the needs of the oil and gas industry. In this paper, we offer new insights on whether the U.S. energy sector has optimally managed the deployment of different types of slack (unused) resources in pursuing investment in R&D and new technologies vs. existing assets and core efficiencies. Using a multi-industry sample of technology-intensive firms provided by the Boston Consulting Group (BCG), our results show that the energy sector's slack resources and R&D investment profile were, on average, markedly different from those in other sectors. The energy sector did not pursue a balanced investment strategy by simultaneously exploiting existing assets and exploring new opportunities – being ambidextrous. Energy was the most "exploitative" and the least "explorative" sector with the highest (the lowest) average capital expenditures (R&D) intensities among the remaining sectors in the sample. The results also show that, in terms of longer-term profitability, the majority of other technology-intensive sectors have significantly outperformed the energy sector.

From a public policy perspective, our results call for more effective regulatory and tax policies focused on enhancing private-sector investment in energy innovation. We further believe as more adaptable technology intensive companies achieve higher profitability over time, energy firms will be pressured to better manage the balance between their slack resources and investment strategies to achieve higher performance through innovation.

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3.1 Introduction

Within an intensely competitive and interdependent global landscape, there is a serious need for a revolution in energy technology and innovation to address fundamental risks relating to energy and national security, environmental sustainability (ongoing reliance on fossil fuels), and economic viability. Recent studies, however, find that overall investment in energy technology and innovation is declining both in the US and globally (Nemet and Kammen 2007; Wisenthal et al. 2009; Doolley 2010). Data from the National Science Foundation (NSF 2010a, b) shows that energy R&D in 2008 represented less than 0.8 % of the total energy expenditure in the US. On the other hand, for the US economy as a whole, the total R&D in 2008 represented 2.8 % of the economy making the ratio of R&D to total expenditure 3.5 times lower for energy than for the economy as a whole. Further, Wiesenthal et al. (2009) estimate that in total, U.S. energy R&D was 1.1 % of all U.S. R&D in 2007, while in the European Union (EU) member states, energy was 2.9 % and in Japan 15.2 % of their total R&D expenditures, respectively.

Globally, the decline in energy innovation investment is most acute in the private sector, and particularly in the US, whose innovation and technology deployment decisions drive much of the world's economic activities. Further, in the US, the private sector's support for energy R&D has been dominated by fossil fuel-based energy investment, mainly related to the needs of the oil and gas industry. Energy sector's increasing focus on fossil foils investment has called into question its commitment to effectively pursue breakthrough opportunities in environmentally significant energy areas such as wind, solar and new technologies. As the worldwide demand for energy is expected to increase by about 40 % over the next 20 years, the energy sector appears to be unprepared (or unwilling) to address emerging technological and environmental challenges and opportunities (IEA 2009; EIA 2010).

Previous studies have taken a macro perspective to study energy innovation. Their findings provide support for the impact of some common factors such as regulatory changes, industry consolidation, and oil price volatility in explaining the aggregate pattern of R&D energy investments over time (Anadon et al. 2011; Henderson and Newell 2010; Nemet and Kammen 2007; Doolley 2010). While these macro insights have been useful, the economic and strategic dynamics of energy R&D investment at the firm level have remained unclear and unexplored. Specifically, it is important to find out whether the US energy sector's observed lack of investment in innovation and new technologies are rooted in its financial and operating strategies, and whether these strategies differ significantly from those of other more adaptive sectors in the economy.

Building on the earlier research from finance and strategy fields (see, for example, Kraatz and Zajac 2001; Voss et al. 2008; Brown and Petersen 2011), Jalilvand and Kim (JK) (2012) have recently developed new perspectives on the dynamics underlying the relationship between organizational adaptability, resources flexibility and performance. JK's main question focuses on how corporations should organize their slack resources and investment strategies to optimally manage the tradeoffs between adapting rapidly to changing market environments versus focusing on core efficiencies. They contend that under general capital market imperfections (i.e., information asymmetries, costly default and constrained access to capital markets), firms achieve superior performance by maintaining a matched (aligned) position between different types of slack resources and investment opportunity sets (options to invest in assets in place vs. future growth opportunities and innovation). Specifically, according to their hypotheses, under stable economic environments, flexible slack resources (cash, marketable securities and lines of credit) should support future growth opportunities, while inflexible slack resources (plant, property & equipment, inventories, excess machine capacity) should be deployed to support core efficiencies. Their findings show that adaptive firms tend to follow the resources and investment matching principle over time to strike the right balance between the need to enhance efficiency vs. strengthening future viability through innovation and breakthrough technological development. JK's (2012) approach has direct relevance to examine the dynamics of R&D investment in the US energy sector during the past several decades. Specifically, it will help unravel the question on whether US energy firms have optimally managed the relationship between their overall slack resources and investment strategies. It should further provide policy makers with a more comprehensive perspective on the dynamics underlying the energy sector's overall investment in innovation and technological development.

The balance of this paper is organized as follows. Section 3.2 provides a general background on the US energy sector's investment in technology and innovation since the inception of the Arab Oil Embargo of 1973. Section 3.3 synthesizes the previous literature on organizational adaptability focusing on the relationship between a firm's slack resources, investment strategies and performance under different market and competitive environments. Empirical propositions pertaining to the resources and investment matching principle are discussed in the fourth section. In Sect. 3.5, data from Compustat industrial files is applied to a sample of multi-industry technology-intensive firms provided by the Boston Consulting Group (BCG). We pursue two separate empirical objectives. First, we examine the US energy sector's overall innovation profile during the period 1990–2011. Second, we compare the energy sector's innovation profile with those of other technology-intensive industries in biotechnology; communications equipments, electronic equipments, instruments, and components; healthcare equipment and supplies; pharmaceutical; information technology; semiconductors and semiconductor equipment; and software. Our sample of 9 broad industries is represented by 110 companies obtained from a comprehensive list of 417 adaptive and highly adaptive firms collected by the BCG representing 59 industries and 9 sectors in the US economy. Conclusions and policy recommendations on energy innovation are presented in the final section.

3.2 Energy Innovation and R&D Investment in the US

The imperative to accelerate the pace at which better energy technologies are discovered and deployed are emphasized by recent studies on energy innovation (Anadon et al. 2011; Henderson and Newell 2010). These studies emphasize the need to improve the efficiency of these investments by providing expanded incentives for private-sector innovation and seizing opportunities where international cooperation can accelerate innovation. In the US, the private sector funds and performs most R&D activities. In 2008, $398 billion worth of R&D was performed by all sectors in the US. Private-sector firms funded $268 billion (67 %) of the total expenditures (NSF 2010a). R&D expenditures represented about 2.8 % of the US overall GDP in 2008 (3.5 times larger than R&D investment proportion in the energy sector). The non-federal funding part is estimated at about 1.9 % of the GDP (NSF 2010b). Wiesenthal et al. 2009 found a similar pattern of R&D investment in the EU. The EU-wide low-carbon energy R&D investment totaled €3.32 billion (roughly $4.5 billion) in 2007 which was split 11 % by the EU, 33 % by member countries, and 56 % by the industry.[1]

Detailed and reliable data on the US private sector energy R&D investment is, however, much more limited. In the US, the vast majority of the energy system is owned by private enterprises. In a recent paper, Dooley (2011) presents two independent datasets that describe investments in energy R&D by the U.S. private sector since the Arab Oil Embargo of 1973. The first dataset is based upon the results of a broad annual survey of more than 20,000 firms' R&D expenditures conducted by the U.S. National Science Foundation (NSF 2010b).[2] Accounting for non-profit investments, Dooley (2011) further combines the NSF/Census survey data with two other datasets that describe private sector energy R&D funding carried out by the Electric Power Research Institute (1997, 2001, 2006) and the Gas Research Institute (1997, 2001) – two large nonprofit US energy research organizations. The second dataset comprises a somewhat more focused accounting of energy R&D activities by the U.S. Department of Energy's Energy Information Agency (EIA) that surveys the R&D activities of a sample of largest U.S. oil and gas companies over the period 1977–2008 (EIA 2010).[3]

Figure 3.1 which is reproduced from Dooley (2011) shows aggregate US private sector expenditures in energy R&D by each of these surveys along with the real price of crude oil. As shown in Fig. 3.1, according to NSF and EIA data, there was a significant surge in energy R&D investment in the immediate aftermath of the Arab Oil Embargo of 1973 reaching as high as $3.7–$6.7 billion per year (in inflation adjusted 2010 U.S. dollars), respectively, between 1980 and 1982. Investments in

[1] These estimates do not include any fossil fuel or energy efficiency R&D.

[2] Starting with the 2006 survey year, however, the NSF and the Bureau of the Census implemented a new survey instrument that did not contain any questions about energy R&D investment (NSF 2010a). Hence, the NSF data used by Dooley (2011) covers only the period 1973–2005.

[3] A list of the firms surveyed can be found at http://www.eia.doe.gov/emeu/perfpro/CoList.html

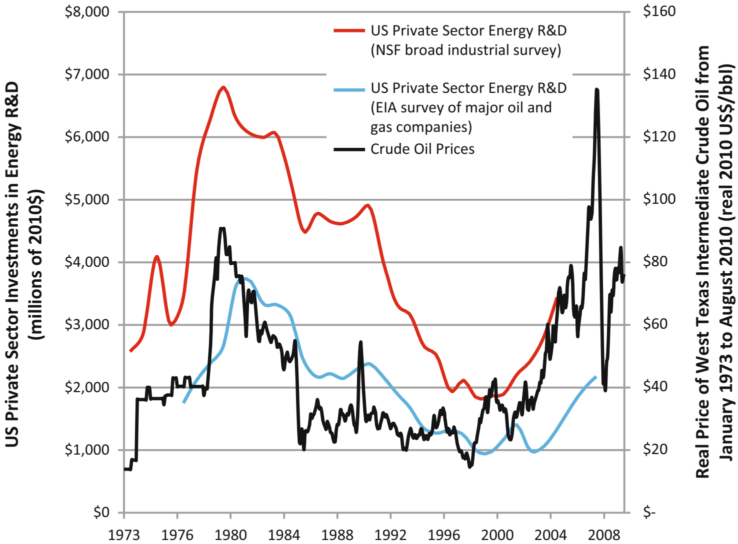


Fig. 3.1 Aggregate U.S. private sector support for all forms of energy R&D (millions of 2010$) compared to the real price of crude oil (2010$/BBL) (Source: Dooley 2010)

energy R&D declined significantly both for the aggregate economy and major US oil and gas companies leveling approximately at $1–$1.8 billion per year in 1999 and began to recover somewhat over the ensuing decade.

According to Dooley (2011), several key factors including the collapse of the oil prices, rapid domestic and global de-regulation of the energy sector, consolidation in the oil and gas industry, and adoption of new production technologies (mainly applied to enhance the efficiency of existing oil and gas operations) have been responsible for the precipitous decline in US energy R&D investment over the decades of 1980s and1990s. U.S. private sector's energy R&D investment has been (and still remains) dominated by fossil fuel sources, particularly those related to the needs of the oil and gas industry in enhancing the efficiency of their core businesses. Further, while the private sector's investments in energy R&D was strongly correlated to real price of crude oil throughout the 1970s and 1980s, its dependence has weakened since the 1990s, possibly indicating a stronger preference for developing non-fossil fuel energy alternatives.

3.3 Organizational Adaptability, Resources and Investment Strategies: A Synthesis

Recently, rapid economic, technological and political changes have significantly increased the level of global turbulence in the business environment, diminishing corporate profitability and survival rates (Stubbart and Knight 2006; Morris 2009). The decline in corporate survival and performance has inflicted significant economic and social costs globally. It has adversely impacted economic growth and has further slowed down the pace of innovation and discovery in the public and private sectors. As global turbulence has continued to increase, researchers and policy makers have begun to focus on strategies and structures that enable corporations to adapt rapidly to changing environments by emphasizing flexibility, learning, experimentation, innovation and cooperation.

In its most general definition, corporate adaptability is viewed as a dynamic capability directed at building and adapting core financial, operational and managerial competencies to address rapidly changing environments. In this process, managers face the basic question on how to balance the benefits and costs of adaptability to enhance performance (Reeves and Deimler 2011). At one extreme, maintaining an external focus with an accompanying ability to adapt to market changes may entail significant opportunity costs associated with forgoing existing competencies. At another extreme, by focusing on a narrowly defined product market, an organization could be exposed to the risk of failing to adapt when market changes occur. An established theme in the strategic management literature is that successful firms are ambidextrous – i.e., investment resources are deployed to maintain a high degree of balance between exploitation and exploration and between alignment and adaptability (Gibson and Birkinshaw 2004; March 1991; Tushman and O'Reilly 1996). Earlier studies often regarded the *tradeoffs* between exploration and exploitation activities as insurmountable, but more recent research describes ambidextrous organizations that are capable of *simultaneously* exploiting existing competencies and exploring new opportunities (Andriopoulos and Lewis 2009; Cao et al. 2009).

More recently, the scope of research on corporate adaptability has been expanded by integrating the fields of strategic change (Rajagapolan and Spreitzer 1987) and the resource-based view of the firm (Schumpeter 1942; Penrose 1958). In this sense, the relationship between organizational adaptability and performance is hypothesized to be influenced both by the role which is played by a firm's investment strategies (exploration vs. exploitation) and management of its slack resources (Kraatz and Zajac 2001; Voss et al. 2008; Lee 2011). Specifically, according to this strand of research, the magnitude and the type of a firm's slack resources determine the nature of its investment strategies which may either focus on future growth opportunities or on enhancing the efficiency of its existing assets. Broadly, slack resources can be categorized along two broad dimensions: *Absorption* and *Specificity (uniqueness)*, emphasizing the different types of resources including financial, operational, customer relational and human resources (Sharfman et al. 1988; Voss et al. 2008). While some resources are relatively generic and commonly available, specific and valued resources such as raw material, people, customer relationship are usually in short supply. Unabsorbed resources such as excess cash, credit lines and unused debt capacity are currently uncommitted and can be redeployed easily within organizations. Organizations also possess absorbed resources such as production capacity and specialized skilled labor that are tied to current operations.

Simultaneously, a growing stream of research has recently emerged in the field of finance focusing on the role of preserving financial flexibility (maintaining appropriate levels of slack resources such as cash and unused debt capacity) to address the needs arising from unanticipated earnings shortfall and new growth opportunities (Gamba and Triantis 2008; Byoun 2008). Focusing on growth options, Myers (1977) and Myers and Majluf (1984) suggest that corporate moral hazard incentives associated with the use of risky debt financing may negatively affect the proportion of a firm's market value accounted for by its investment in future growth opportunities – normally, a significant part of many firm's market valuation. More recently, Brown et al. (2009) and Brown and Petersen (2011) find that firms with significant growth opportunities, but facing financing frictions, appear to build cash reserves when cash flow and stock issues are high and then draw them down in years when equity is less available in order to maintain a relatively smooth path of R&D spending for innovation and growth opportunities. Put differently, their results support the view that firms maintain the trajectory of their R&D investment by actively managing their liquidity decisions.

Previous empirical findings on the performance implications of corporate adaptability are inconclusive. Miles and Snow (1978), in their typology of organizational strategies (reactor, defender, analyzer, and prospector), postulate that the more active a firm is in its pursuit of new product-market opportunities, the more adaptive capability it will build into its tactical base. However, they find no significant differences in performance among different strategy types.[4] Bourgeois (1980), on the other hand, hypothesized that the relationship between performance and adaptive capability (measured by the presence of slack resources) would be positive, up to a point, then negative; in other words, a curvilinear relationship was hypothesized. McKee et al. (1989) found support for a balanced investment strategy approach where firms deploy resources both to advance their core efficiencies and search for new growth opportunities.

3.4 Organizational Adaptability and Matching of Resources and Investment Strategies

Previous research on organizational adaptability has typically treated the process of managing a firm's slack resources and its strategic investment decisions (choice between efficiency and innovation) separately and in isolation (Kraatz and Zajac 2001; Voss et al. 2008; Lee 2011). As depicted in Fig. 3.2, however, Jalilvand and Kim (2012) propose an integrated decision making framework to characterize the overall relationship between corporate adaptability and performance. Following their approach, a firm's Investment Strategies and Management of Slack Resources

[4] These four strategy types reflect a continuum of increasing adaptive capability ranging from the reactor (with relatively little adaptive capability) to the prospector (with the highest level of adaptive capability).

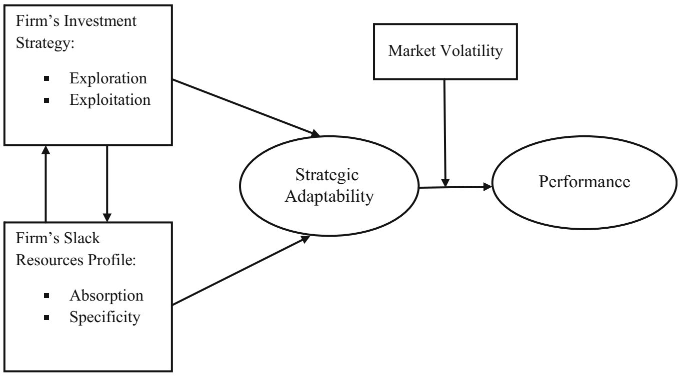


Fig. 3.2 Strategic investment, slack resources and long-term performance process

are simultaneously determined to sustain competitive advantages and derive performance. This relationship is further assumed to be moderated by the level of turbulence in the market environment. Conceptually, their proposed framework is consistent with a large body of previous research which recognizes that costs and imperfections inherent in markets (information asymmetries, transactions costs, real economies of scale or scope, forms of taxation, etc.), may cause substantial economic interactions among a firm's decisions, in addition to those imposed by the basic sources and uses of funds constraints (see Graham and Harvey 2001; Gamba and Triantis 2008; Jalilvand and Harris 1984).

Attempting to maximize long-run performance, JK (2012) further contend that firms should simultaneously match (align) the type of slack resources they hold with the nature of the investment opportunities they are facing. In the long-run, matched firms will outperform rivals with a mismatch between slack resources and investment strategies. The increased performance of matched firms reflects economies captured by mitigating costs associated with information asymmetries, avoiding external capital market frictions and lowering the risk of default.

The dynamics of the proposed matching principle is depicted graphically in Fig. 3.3 where all firms which have achieved a proper balance between slack resources and investment strategies are located on the Resources-Investment Efficient Frontier (firms A, B and C). In the long run, mismatched firms with inferior performance will be forced to adjust their slack resource and investment profile to move toward a more efficient resources-investment position.

JK (2012) also propose a series of propositions to test the empirical validity of their model. These propositions can be directly applied to examine the dynamics of R&D investment in the US energy sector. More specifically, they will help unravel the question on whether US energy firms have been optimally managing the relationship between their overall slack resources and investment strategies by simultaneously investing in core efficiencies and future growth opportunities. Following JK (2012), we use two broad propositions to examine the adaptability/performance dynamics of the energy firms:

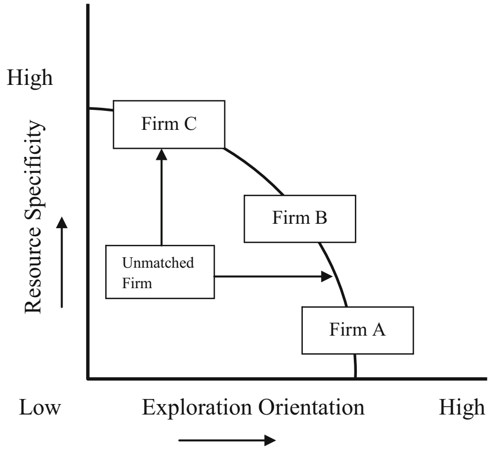


Fig. 3.3 Resource-investment efficient frontier

H1: In the long-run, energy firms' investment strategies are determined to maximize performance by simultaneously exploiting existing competencies and exploring new opportunities – being ambidextrous.

H2: In the long-run, energy firms' slack resources and investment strategies are jointly managed to maximize performance by

(a) *maintaining a positive relationship between flexible slack resources (i.e., both low absorption and low specificity, such as financial slack) and exploration-oriented investment, and*

(b) *maintaining a positive relationship between inflexible slack resources (i.e., both high absorption and high specificity, such as production capacity, human resources, etc.) and exploitation-oriented investment.*

3.5 Data, Sample and Variable Definition

We apply data from Compustat industrial files to a sample of multi-industry technology-intensive firms provided by the Boston Consulting Group (BCG). We have two separate empirical objectives. First, we examine the US energy sector's overall innovation profile during the period 1990–2011. Second, we compare the energy sector's innovation profile with those of other technology-intensive industries in biotechnology; communications equipments, electronic equipments, instruments, and components; healthcare equipment and supplies; pharmaceutical; information technology; semiconductors and semiconductor equipment; and software.[5] Our sample of 9 broad industries is represented by 110 companies obtained

[5] Energy sector combines Energy Equipment and Services with Oil, Gas, and Consumable Fuels. Information Technology Services combine the IT Services with Internet Software and Services.

from a comprehensive list of 417 adaptive and highly adaptive firms collected by the BCG representing 59 industries and 9 sectors in the US economy.[6]

According to the BCG, a firm's degree of adaptability is measured by using an Adaptive Advantage Index (AAI) constructed from a sample of 2,500 US public companies over a 6 year period, 2005–2011. Specifically, a company's AAI is measured by its industry adjusted cumulative market cap growth rate during seven most turbulent quarters over a 6 year period, October 2005 through September 2011.[7] Two sample selection adjustments are also made. Firms in the financial sector are excluded because of the potential performance bias introduced by regulatory and government interventions. Similarly, companies with major M&A activities are excluded to control for any performance bias created by corporate restructuring activities. BCG's detailed procedure in calculating the index is provided in Appendix 1.

Following Brown et al. (2009) and Brown and Petersen (2011), a firm's innovation profile is characterized by a set of variables describing its overall financial and operational flexibility and the nature of its investment activities.[8] Specifically, it captures the level and type of a firm's slack resources (cash holdings, long term debt, equity, and plant, property and equipment); and the nature of its investment opportunities and growth prospects (R&D, capital expenditures, sales growth, market to book ratio, and return on asset). These variables are explained below.

$(\text{Capex})_t$	Capital expenditures in period t divided by the book value of total assets at the beginning of period t
$(\text{R\&D})_t$	Research and development expense in period t divided by the book value of total assets at the beginning of period t
$(\text{SalesGrowth})_{t,\ t-1}$	Log of change in net sales between period t and t−1
$(\text{CashHoldings})_t$	Cash and short-term investments in period t divided by the book value of total assets at the beginning of period t
$(\text{Equity})_t$	Common shareholders' interest in the company at the beginning of period t divided by the book value of total assets at the beginning of period t
$(\text{LTDebt})_t$	Debt obligations due in more than 1 year at the beginning of period t divided by the book value of total assets at the beginning of period t

(continued)

[6] The list of sample firms of nine technology-intensive sectors used in this study is available from the authors upon request.

[7] In the BCG approach, periods of turbulence for a given industry refer to environments when large changes in aggregate demand, competition, operating margins and market expectations occur. In a recent study, Reeves et al. (2012) also use the BCG sample to study corporate sustainability as a dynamic capability.

[8] While Brown and Petersen (2011) use changes in variables, Brown et al. (2009) use levels in their study. The use of changes in variables may be more relevant in a multivariate analysis setting.

$(\text{Property})_t$:	Cost, less accumulated depreciation, of tangible fixed property used in the production of revenue at the beginning of period t divided by the book value of total assets at the beginning of period t
$(\text{Market Book})_t$:	Market value of assets in period t−1 divided by the book value of total assets in period t−1, where market value of assets is equal to the market value of equity plus the book value of assets minus the book value of equity
(Return on Asset: $\text{ROA})_t$:	Gross cash flow in period t divided by the book value of total assets at the beginning of period t, where gross cash flow is defined as (after-tax) income before extraordinary items plus depreciation, amortization and research and development expense

3.6 Results

Before we proceed with the analysis of our data, a few observations on the implications of using the BCG sample may be in order. Overall, as explained above, according to the BCG's definition, "adaptable" firms are those who have outperformed their industries during several consecutive periods of turbulence from 2005 to 2011. However, in this study, following JK (2012), we offer specific propositions (such as matching and ambidexterity) to explain the financial and strategic dynamics underlying the relationship between organizational adaptability and performance. Hence, a priori, we are empirically testing a joint hypothesis reflecting both the validity of the model's propositions and accuracy of the BCG's approach in selecting adaptive firms.

The descriptive statistics and two tailed comparative t-tests are presented, respectively, in Tables 3.1 and 3.2. Overall, the results show that the energy firms' innovation profile, characterized by the pattern of their resources and investment strategies, were, on average, markedly different from those in the other eight sectors (comparison group). Specifically, with the exception of their extensive commitment to capital expenditures investment, the energy sector, on average, has maintained significantly lower R&D, cash holdings, long-term debt, equity, market to book and sales growth among the majority of the other sectors in our sample.[9] Using average return on assets as a measure of long-term profitability, we also observe that five out of eight sectors have significantly outperformed the energy sector. The profitability ratios in the remaining three sectors are not statistically different from that of the energy sector.

The trend lines in Figs. 3.4 and 3.5 capture differences in the pattern of slack resources and investment strategies for the energy sector and the comparison group over the entire period, 1990–2011. As shown in Fig. 3.4, starting with 2000, the

[9] In our sample, firms in the energy sector have, on average, maintained significantly lower equity ratios than firms in the comparison group. This pattern of financing is consistent with the differential nature of the investment strategies pursued by the energy sector vs. those in the comparison group (i.e., assets in place vs. growth opportunities, Brown et al. (2009)). The differences in long-term debt behavior are less significant.

Table 3.1 Adaptive BCG companies in technology-intensive industries, 1990–2011

Variables[a]		Energy	Electronic equipments	Health care equipment	Information technology	Pharmaceuticals	Software	Communications equipments	Semiconductors	Biotechnology
MarketBook	Mean	2.0068	2.0522	2.8643	4.0488	3.2323	3.6920	4.2906	3.5501	4.9335
	Median	1.8683	1.7822	2.4971	2.4849	2.5646	2.8574	2.2992	2.7518	3.6664
Assets	Mean	38,723.74	990.09	4,349.63	16,823.06	4,500.81	9,848.09	1,973.19	6,953.98	3,075.63
	Median	8,616.10	692.83	2,407.33	995.95	758.15	2,001.59	642.21	2,855.68	330.41
Capex	Mean	0.0779	0.0373	0.0410	0.0538	0.0398	0.0375	0.0429	0.0762	0.0458
	Median	0.0735	0.0274	0.0395	0.0353	0.0313	0.0262	0.0311	0.0536	0.0310
R&D	Mean	0.0124	0.0510	0.0514	0.0627	0.1048	0.1204	0.1324	0.1371	0.2661
	Median	0.0066	0.0194	0.0436	0.0476	0.0720	0.1085	0.1060	0.1201	0.1933
Equity	Mean	0.4130	0.4848	0.5376	0.5176	0.5154	0.5240	0.5642	0.6515	0.5553
	Median	0.4352	0.5065	0.5455	0.6292	0.5459	0.5669	0.6895	0.6965	0.6454
LTDebt	Mean	0.1429	0.1796	0.1763	0.1062	0.1652	0.0522	0.1073	0.0990	0.1950
	Median	0.1212	0.0754	0.1819	0.0037	0.1017	0.0024	0.0003	0.0470	0.0638
SalesGwth	Mean	0.0636	0.1621	0.1220	0.2857	0.2125	0.2236	0.2594	0.1945	0.4021
	Median	0.0698	0.1501	0.0770	0.1629	0.1205	0.1846	0.1892	0.1534	0.2939
CashHoldings	Mean	0.0917	0.1120	0.1307	0.3855	0.2399	0.3700	0.3504	0.3357	0.5734
	Median	0.0616	0.0662	0.0703	0.3920	0.1745	0.3542	0.3380	0.3231	0.5818
ROA	Mean	0.1225	0.1328	0.1520	0.0892	0.1617	0.2254	0.1664	0.2635	0.1238
	Median	0.1295	0.1175	0.1600	0.1579	0.1831	0.2248	0.1812	0.2813	0.1293
Observations[b]		162	138	155	156	158	164	156	200	172

[a]Variables used in the study are from Brown et al. (2009) and Brown and Petersen (2011)
[b]The sample is provided by the Boston Consulting Group

Table 3.2 T-test of mean comparisons across technology-intensive sectors

		Electronic equipments	Health care equipment	Information technology	Pharmaceuticals	Software	Communications equipments	Semiconductors	Biotechnology
MarketBook	Difference[a]	0.0454	0.8575	2.0420	1.2256	1.6852	2.2838	1.5434	2.9267
	|t| value	0.3691	4.4690	2.1094	5.7768	5.9085	2.7235	3.1914	6.2765
	Pr (|T| > |t|)[b]	0.7125	0.0000***	0.0361**	0.0000***	0.0000***	0.0070***	0.0016***	0.0000***
Capex	Difference	−0.0406	−0.0369	−0.0241	−0.0381	−0.0404	−0.0351	−0.0017	−0.0321
	|t| value	8.3425	8.6037	3.5171	7.7670	8.6305	7.1411	0.2776	6.0637
	Pr (|T| > |t|)	0.0000***	0.0000***	0.0005***	0.0000***	0.0000***	0.0000***	0.7814	0.0000***
R&D	Difference	0.0386	0.0390	0.0371	0.0924	0.1080	0.1200	0.1247	0.2537
	|t| value	5.9825	6.6960	10.5559	9.6156	17.7813	15.0901	22.6979	13.3296
	Pr (|T| > |t|)	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***
Equity	Difference	0.0718	0.1246	0.1046	0.1024	0.1110	0.1512	0.2385	0.1423
	|t| value	2.6710	6.0999	3.0901	3.3541	2.9806	3.9675	11.9527	3.3026
	Pr (|T| > |t|)	0.0080***	0.0000***	0.0022***	0.0009***	0.0031***	0.0001***	0.0000***	0.0011***
LTDebt	Difference	0.0367	0.0334	−0.0367	0.0224	−0.0907	−0.0356	−0.0439	0.0521
	|t| value	1.6385	2.6001	1.8771	1.1303	7.4669	1.9260	3.5090	2.4196
	Pr (|T| > |t|)	0.1024	0.0098***	0.0614*	0.2592	0.0000***	0.0550*	0.0005***	0.0161**
SalesGwth	Difference	0.0985	0.0584	0.2221	0.1489	0.1600	0.1958	0.1309	0.3385
	|t| value	3.7621	2.4473	4.8840	3.3449	5.5308	4.8421	4.0197	5.5236
	Pr (|T| > |t|)	0.0002***	0.0150**	0.0000***	0.0009***	0.0000***	0.0000***	0.0001***	0.0000***

(continued)

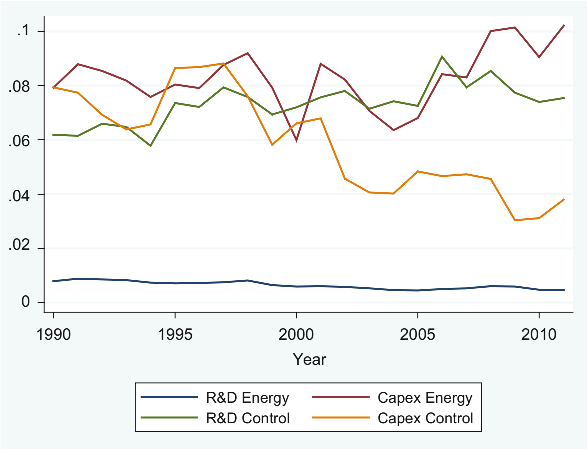
Table 3.2 (continued)

		Electronic equipments	Health care equipment	Information technology	Pharmaceuticals	Software	Communications equipments	Semiconductors	Biotechnology
CashHoldings	Difference	0.0202	0.0390	0.2938	0.1482	0.2783	0.2587	0.2440	0.4817
	|t| value	1.6426	2.6745	15.3703	7.6623	17.5024	16.1564	16.5430	24.6984
	Pr (|T| > |t|)	0.1015	0.0079***	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***
ROA	Difference	0.0103	0.0295	−0.0333	0.0392	0.1029	0.0439	0.1410	0.0013
	|t| value	0.8261	2.8939	0.8946	2.6410	7.4303	2.6568	11.6247	0.0737
	Pr (|T| > |t|)	0.4094	0.0041***	0.3717	0.0087***	0.0000***	0.0083***	0.0000***	0.9413

[a] Mean difference between individual industries in the comparison sector and energy sector: positive (+) values indicate that other sector > energy sector

[b] When Ha: diff $\neq 0$ is statistically significant the results are marked with *($p < 0.10$), **($p < 0.05$), *or* ***($p < 0.01$): two-tail tests

Fig. 3.4 R&D and capital expenditures trends: energy versus comparison group



energy sector and the comparison group experienced diametrically opposite patterns of capital expenditures. The energy sector continued to build its capital expenditures while the comparison group experienced a steady decline.[10] Also, the gap in capital expenditures between these sectors continue to widened post 2000 reflecting a differential focus on investment strategies: core businesses and efficiencies vs. future growth opportunities.[11] It is also worth noting that the capital expenditures expansion in the energy firms was strongly correlated with increases in the real price of crude oil which began in 2005. Conversely, the energy firms' average R&D expenditures were negligible, hovering around 1 % of total assets during the entire period, 1990–2011.[12] This observation is contrary to the rising pattern of energy R&D expenditures in response to significant increases in crude oil prices following the Arab Oil Embargo in 1973. Rather, under a different oil price regime post 2005, our results suggest that energy firms may have committed their

[10] In the energy sector, annual number of firm/year observations is evenly distributed throughout the period of 1990–2011 (22 years). Further, the yearly means and standard deviations of energy companies are stable. Accordingly, we did not find any evidence that data availability or variation would affect our findings and conclusion in the paper.

[11] Typically, energy firms possess a higher level of tangible assets than those in the comparison group. However, the impact of asset tangibility on innovation (R&D intensities) is not entirely obvious. Firms with higher levels of tangible assets may choose to focus their investments more on their existing assets. On the other hand, firms with higher tangible assets may face more moderate external financing restrictions due to their lower expected costs of default. In turn, these firms may opt to use their increased external financing advantages to invest more heavily in future growth opportunities and innovation.

[12] Figure 3.4 only shows a mild reduction in the energy sector's R&D intensity. However, the true reduction in the energy sector's R&D intensity is masked due to scaling required to include all trend-lines (energy and the control group sectors) in one graph. Using a narrower scaling range, we observe that the energy sector's R&D intensity did actually decline over the entire period, 1990–2011.

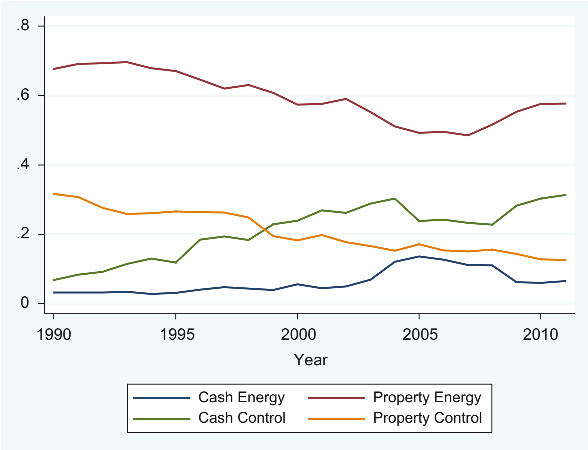


Fig. 3.5 Cash holdings and plant/property/equipment trends: energy versus comparison group

additional revenues obtained from increases in crude oil prices to expand the efficiency and productivity of their existing assets (possibly in fossil fuel) as opposed to investing in future innovation and technology development in wind and solar areas. On the other hand, the comparison group began to systematically increase its R&D expenditures in mid 1990s while reducing its overall capital expenditures over the same period.

From the point of view of managing the portfolio of slack resources, Fig. 3.5 shows that plant, property and equipment (Property) have consistently played a significant role in supporting the energy sector's overall investments (mainly in core efficiencies). While both sectors increased their cash holdings (CashHoldings), the comparison group both maintained higher levels of cash holdings and grew them more rapidly than what occurred in the energy sector. The comparison group's slack resources and investment behavior over time also appear to be consistent with the implications of proposition H2(a, b) as (i) increases in R&D expenditures are trending positively with increases in average cash holdings and short term securities and (ii) decreases in capital expenditures are positively trending with decreases in plant, property and equipment. On the other hand, in the energy sector, slack resources and R&D or capital expenditures do not appear to be correlated.

In Fig. 3.6, we further examine the individual sectors' investment (ambidexterity) profile (proposition H1) by plotting each sector's average values of R&D and capital expenditures intensities. Not surprisingly, the energy sector is identified as the most "exploitative" and the least "explorative" sector with the highest (the lowest) average capital expenditures and (R&D) intensities among the remaining eight sectors. On the other hand, with the highest average R&D intensity, biotechnology is the most "explorative" sector which has also achieved a moderate level of exploitative investment. The investment strategies of the remaining seven sectors or industries are more balanced as they appear to be simultaneously exploiting existing competencies and exploring new opportunities – being ambidextrous

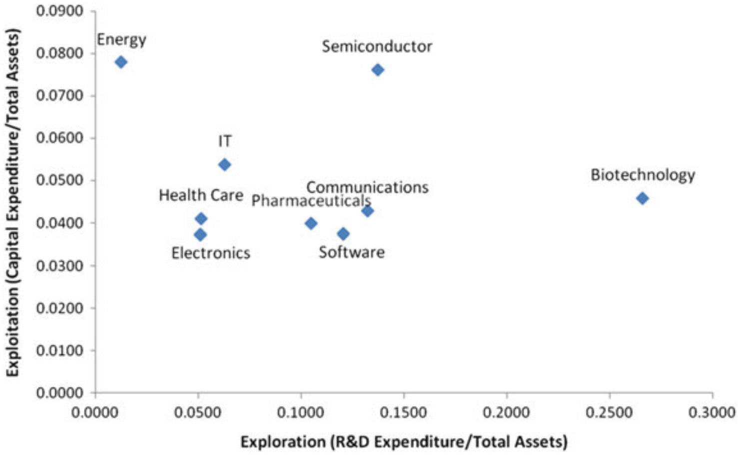


Fig. 3.6 Ambidextrous investments for exploration and exploitation: multi industry comparison

(Cao et al. 2009; Gibson and Birkinshaw 2004; Tushman and O'Reilly 1996). Interestingly, we also find that sectors characterized by a stronger ambidexterity profile (Communication Equipments, Healthcare Equipment and Supplies, Pharmaceutical, Semiconductors and Semiconductor Equipments and Software) have outperformed the energy sector based on the average return to asset measure of performance.

Finally, in Fig. 3.7, we investigate more directly the resources and investment matching proposition H2(a, b) by plotting individual sectors based on average values of their overall slack resources specificity vs. the extent of their exploratory investments. A firm's slack resources specificity measured by [Property, Plant, and Equipment/(Property, Plant, and Equipment + Cash Holdings)] is expected to proxy the extent of the available resources which are already committed to the current operations such as production capacity and specialized skilled labor. Further, the extent of a firm's exploratory investment is measured by the ratio [R&D/(R&D + Capital Expenditures)]. Again, the energy and the biotechnology sectors are plotted in opposite directions with energy identified as a sector with the highest resources specificity level and the lowest exploratory orientation among all sectors. On the other hand, biotechnology is identified as a sector with the highest level of exploratory investment among all sectors and with a moderate level of resources specificity. The remaining sectors are plotted between these two extreme cases as they are endowed with more moderate levels of resources specificity and exploratory orientation. Overall, in Fig. 3.7, the plot of all sectors (considered to be adaptive by BCG) appear to approximate well our proposed Resources-Investment Efficient Frontier where all firms which have achieved a proper balance between slack resources and investment strategies are expected to be located.

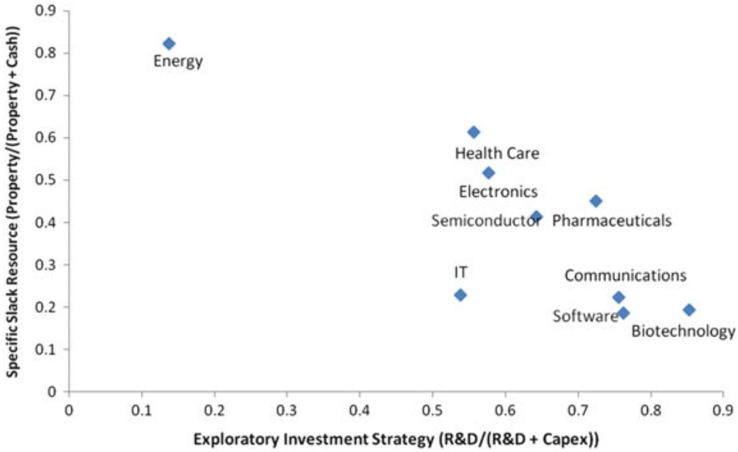


Fig. 3.7 Matching of slack resources and investment strategies: multiple industry comparison

Concluding Remarks

In this paper, we examine the firm-specific dynamics of innovation in the US energy sector. We further compare the energy sector's innovation profile with those of several other technology-intensive industries in biotechnology; communications equipments, electronic equipments, instruments, and components; healthcare equipment and supplies; pharmaceutical; information technology; semiconductors and equipment; and software. Our results provide evidence showing that, beyond macroeconomic influences, firm-specific factors have played an important role in explaining the energy sector's observed lack of adaptability captured by very low rates of R&D intensity over time. Further, the energy sector's slack resources and R&D investment profile was found, on average, to be markedly different from those in other sectors. The results also show that, in terms of longer-term profitability, the energy sector was significantly outperformed by the other technology-intensive sectors.

We also find that the capital expenditures expansion in the energy sector was strongly correlated with increases in the real price of crude oil which began in 2005. Conversely, its R&D expenditures were negligible and declined during the period, 1990–2011. This observation is contrary to the rising pattern of energy R&D expenditures occurred following significant increases in crude oil prices post Arab Oil Embargo in 1973.

Unlike the other technology-intensive sectors, the energy sector did not pursue a balanced investment strategy by simultaneously exploiting existing competencies and exploring new opportunities – being ambidextrous. Energy was the most "exploitative" and the least "explorative" sector among the remaining sectors in the sample. Further, the energy sector slack resources and investment strategies did not conform to our proposed matching principle. On the other hand, for the comparison group, R&D expenditures trended positively with increases in average cash holdings while decreases in capital expenditures also trended positively with decreases in plant, property and equipment.

We recognize that the BCG sample does not represent the entire spectrum of the US industries. In this sense, the scope and the scale of our sample is somewhat limited. However, BCG's sample provides a unique opportunity to verify the relevance of Jalilvand and Kim (2012) propositions for a group of "adaptive" firms who have outperformed their industries during several consecutive recent periods of turbulence. Thus, our results may support a joint hypothesis encompassing both the relevance of Jalilvand and Kim (2012) theoretical predictions vs. the validity of the BCG's approach in identifying adaptive firms. We also call for the development of more robust and dynamic econometric models of a firm's slack resources and investment decisions under varying market environments.

From a public policy perspective, our results call for a better integration of macro and micro policies including regulatory and tax legislations directed to enhance global energy innovation. We further believe as more adaptable technology intensive companies achieve higher profitability over time, energy firms will be pressured to better manage the balance between their slack resources and investment strategies to become more adaptable and responsive to their changing environments.

Appendix 1: BCG Sample Description

The BCG Adaptive Advantage Index (2012) was created using publicly available data for 2,500 U.S. public companies across a wide range of industries. Each company's BCG Adaptive Advantage Index score was calculated by measuring the weighted-average outperformance of a company's market-cap growth rates versus the weighted-average market-cap growth rates in its industry during that industry's seven most turbulent business quarters from October 2005 through September 2011. Throughout the report, this 6-year period is referred to as 2006–2011. The BCG index categorized companies using the Global Industry Classification Standard (GICS) which was developed by MSC I and Standard & Poor's.

Outperformance was measured in terms of market-cap growth rates because market-cap correlates strongly with total shareholder return (TSR) and, ultimately, with value generation. It also conveys information about past and potential future performance; also, market-cap data are available in greater detail than are other measures of performance. The fluctuations of stock market prices, typically over shorter intervals, are mitigated since market-cap growth rates were measured over each quarter and averaged over the 6-year period.

Periods of turbulence were identified for each industry by assessing turbulence in demand, competition, margins, and capital market expectations. Turbulence in demand and margins was measured by the absolute rate of change in industry revenues and EB IT margins, respectively, per quarter. Turbulence in competition was measured by taking the weighted average of the absolute change in companies' rankings by revenues within an industry each quarter. To account for company size, we weighted the average using company revenues.

Turbulence in the capital market expectations of an industry was measured by taking the weighted average of the standard deviations of daily market-cap growth rates of the industry's companies over a quarter. To account for company size, we weighted the average using company market-cap.

These four measures were combined and adjusted for any cross-correlations among them to create a net turbulence metric. This net turbulence metric was used to identify the seven most turbulent periods in each industry; the companies' average relative outperformance in market-cap growth was then calculated during those seven turbulent periods, as outlined above, to determine its index score.

An index score of 105 means that, on average, the company outperformed its industry by 5 % points during a single turbulent quarter – a major achievement in tough times, and a performance effect that can compound significantly over time. If, for example, the turbulent quarters were sequential, such a score would, by compounding over seven quarters, translate into a 41 % outperformance in market-cap growth over the industry. The level of adaptiveness of each company was determined relative to other companies in its industry: in each industry, the top 50 % of companies achieving scores at or above 100 on the adaptiveness index were classified as highly adaptive and the bottom 50 % as adaptive. The ten largest companies (as measured by revenues) in each industry were then selected to compile these tables.

Companies belonging to the financial sector (as designated by GICS codes) were excluded from the index because government intervention in the sector had a distorting effect on the outperformance exhibited by certain companies. Similarly, we excluded companies whose marked increase in outperformance during turbulent periods was coincident with major M&A activity.

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Measuring Risk in Energy Markets

4

Bert Scholtens and Konstantionos Sklavos

Abstract
In this chapter we intend to provide the practitioner and academic interested in energy markets with an overview of the most popular risk measures and how they can be utilized for energy assets. These risk measures differ on their construction and focus since risk is not straightforwardly quantified. We discuss the advantages and limitations of each measure and we apply these methods in electricity, natural gas, and crude oil energy assets.

4.1 Introduction

Energy has been a crucial input for industrial production the last centuries. While initially industries and countries were using energy sources that were in close proximity, with the development of global trade and reduction of time and cost of trading, they have been using sources that may be at the other end of the planet. The electrification of energy usage gave an enormous impetus to this transition. The strategic importance of energy sources has raised many tensions and even wars among countries (Brundtland et al. 1987). As such, energy access and security and the uncertainty about this access remain to be an important issue. The geographical distribution and the resulting concentration of energy resources in the world

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increasingly seem to result in a very volatile price. From a practical perspective, this is due to the transportation costs, storage limitations, and supply and demand conditions. Thus, this volatile price raises a risk not only for the fundamental need for energy security but also regarding the cost of it. This distinct characteristic of energy assets positions them as a crucial part of the modern global economy. Changes in energy prices may affect global economic trends and exacerbate or even initiate crises.

Energy prices affect macroeconomic aggregates such as Gross Domestic Product, Inflation or Unemployment (Hamilton 1983). Rasche and Tatom (1981), show that sharp increases in the energy prices have reduced the economic capacity of the six countries they investigate. Mork et al. (1994), investigating seven OECD countries, also find that the correlation of oil prices and real output is negative for six countries with the exception of Norway, which is an oil producing country and benefits from oil price increases.

Energy price volatility is a crucial topic to investigate since energy is a key ingredient in the production of most goods and services. Oil price volatility has been shown to affect the strategic investment decision of firms (Henriques and Sadorsky 2011). This is due to the energy input uncertainty: The more volatile the price of the inputs of a firm, the more risk this involves for an irreversible investment. Thus, firms may postpone investment in periods of high uncertainty.

The importance of energy prices in macroeconomic variables and strategic decisions is magnified due to the fact that energy prices are very volatile, which increases uncertainty. Plourde and Watkins (1998) find that between 1985 and 1994 oil prices have been at least as volatile as nine other commodities (eight metals and wheat). Regnier (2007) finds that crude oil prices are much more volatile than other products manufactured in the US, and during the last 20 years the differential has become more pronounced.

In the literature, different risk measures have been used in an attempt to arrive at a more precise estimation of the risk involved in energy prices. For example, Narayan and Narayan (2007) model oil price volatility using an EGARCH model to capture for two typical features of oil price volatility, namely asymmetry and persistence of shocks. GARCH type models for the volatility clustering and have been used also in modeling electricity prices (Escribano et al. 2011). They observe there is seasonality, mean-reversion, jumps and volatility clustering in these prices. Cabedo and Moya (2003) investigate the quantification of oil price risk using a Value at Risk methodology. They use a variety of procedures, either with historical simulation or with Variance-Covariance methods. Sadeghi and Shavvalpour (2006) use historical simulation and ARMA and Variance-Covariance modeling VarR approaches.

Another point of view is to look into the energy assets on the basis of a portfolio perspective. Portfolio construction and diversification has been used for many asset classes and plays a useful role in decision making. For example, Humphreys and McClain (1998) suggest that an energy mix of the US energy consumption can reduce the risks of unanticipated energy prices shocks. Instead of trying to reduce the exposure to the prices of a specific energy asset, diversifying the energy sources may have similar wealth effects on the basis of portfolio diversification.

Risk measurement equips us with fundamental tools in decision making. However, there is no single perspective or methodology that dominates on how exactly we should measure risk. There is a wide range of risk measures with distinct technical properties and practical features. In this chapter we will briefly explain and elaborate on the most commonly used risk measures and will describe their main advantages and their limitations. In Sect. 4.2 we will provide an introduction to the main risk measures and their construction. In Sect. 4.3 we view how related risk measures have been used for energy assets in the literature. In Sect. 4.4 we describe the data and discuss qualitatively the applications regarding the energy assets. In Sect. 4.5 the results on the risks measures of energy assets are illustrated and the section "Conclusion" concludes the chapter.

4.2 Risk Measures

In this section we will introduce the most popular measures of risk and elaborate on their construction and use. Later on, we introduce the data for which we will apply these risk measure and we will demonstrate the results for specific energy assets. The first part of this section deals with volatility and standard deviation and GARCH. The second part introduces Value at Risk. The third part explains two relative indices, namely the Sharpe Ratio and covariance.

4.2.1 Volatility

Volatility is a general measure of the dispersion of the returns of an asset. Typically, it is measured with the use of the standard deviation of the returns. The higher the standard deviation or volatility, the more risky an asset is. In other words, standard deviation or volatility provides us with a measure regarding the changes in the value of an asset. Low volatility would imply that we are not expecting large changes in the value/price of an asset over a particular period of time. In contrast, high volatility implies that there may be very large swings, both upwards and downwards, over a specific period of time. Given that individuals are risk-averse, most firms and private households prefer less volatility (and hence less risk) for a given return.

4.2.1.1 Standard Deviation

The simplest and most straightforward measure of volatility is the standard deviation. The standard deviation is the square root of the variance of a population and is showing the dispersion of the data from their mean. Variance is the second central moment and can be described as the probability weighted sum of the squares of the deviation from the mean (i.e. the first moment). In a given sample of i observations for the x variable, x_i is the i'th observation of the x variable. The mean (average) of the sample is μ and the standard deviation is σ.

Where:

$$\mu = \frac{\sum_{1}^{i} \chi_i}{i} \tag{4.1}$$

$$\sigma = \sqrt{\frac{\sum {x_i}^2}{i} - (\mu)^2} \tag{4.2}$$

In order to grasp more information regarding the distribution of a data series it is advisable to use also higher moments such as skewness (third moment) and kurtosis (fourth moment).

4.2.1.2 GARCH

During the 1980s there has been a huge methodological advance regarding the description of volatility. The empirical literature was increasingly witnessing a pattern of volatility clustering in various markets. During times of high volatility, it is expected that this high volatility persists and does not quickly fade away. In the 1980s a new methodology had been introduced to describe this persistence in volatility and shaped a new modeling procedure for time series, namely, (Generalized) Autoregressive Conditional Heteroskedasticity (G)ARCH. Later, many extensions and specifications did follow.

A GARCH (p, q) would imply a volatility of:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2 \tag{4.3}$$

Where:

ε_t denotes the error terms

$\sigma = \sqrt{\frac{\sum x_i^2}{i} - (\mu)^2}$ as defined in (4.2)

t is the time according to the frequency of our data sample. Depending on our selection on how long this period (t) should be, it implies distinct forecasts of volatility.

α_i: indicates the coefficients for lag i we consider with regards to the previous error terms

β_i: indicates the coefficients for lag i we consider with regards to the previous volatility

For p = 0 (implying that lagged volatility does not matter) GARCH reduces to ARCH.

For q = 0 (and p = 0) GARCH simplifies to constant volatility.

Notice the difference with the standard deviation measure where the volatility was constant while now is time varying.

4.2.2 Value at Risk

Value at Risk (VaR) is a statistical approach which measures a potentially high loss from asset holdings. This measure provides us with the possible loss estimation under normal market conditions. Usually, it is constructed to describe the likely loss under these normal market conditions, and a small probability of higher losses. Generally in the global economy and especially in energy markets there is an extreme risk potential from value destruction. A nice discussion about extreme losses, natural disasters and distributional characteristics is given in Kousky and Cooke (2009). VaR has the flexibility to address extreme loss scenarios given the suitable probability. The abnormal probability level (in percentage) that one sets depends on the choice of the risk manager or the regulator when it concerns institutions. Having decided on the probability we consider as abnormal, we can use different holding periods to describe the possible loss over this period. For instance, an argument could be that "with 95 % probability our losses over the next 10 days are not expected to be more than X". There are three main parameters that are determining the Value at Risk concept, namely time horizon, confidence level, and the unit of measurement. In this chapter we assume a normal distribution and the unit of measurement will be the returns of the energy assets prices. Then the 99 % Value at Risk (maximum loss) would be:

$$\mathrm{VaR} = \mu - Z_{0.01}{}^{*}\mathrm{SE} \tag{4.4}$$

Where:

μ = mean return of the prices over the period examined

$$\mu = \frac{\sum_{i-n}^{i} r_i}{n}$$

$Z_{0.01} = 2.33$ (Z is the cumulative distribution function of the standard normal P ($z > 2.33$) = 1 %)

SE = the standard error of the returns

$$\mathrm{SE} = \frac{\sigma}{\sqrt{n}}$$

σ = standard deviation as defined in (4.2)

4.2.3 Benchmarks

4.2.3.1 Sharpe Ratio

When we are dealing with risk levels, we should also account for the risk and return trade-off. In this respect, Sharpe ratio (Sharpe 1966) is a traditional measure that measures relative risk with respect to the relevant benchmark and is constructed as:

$$\mathrm{S} = \frac{E(r_i - r_b)}{\sigma} \tag{4.4}$$

Where:
r_i: is the return of the asset
r_b: is the return of the benchmark
σ: is the standard deviation of the excess return $(r_i - r_b)$

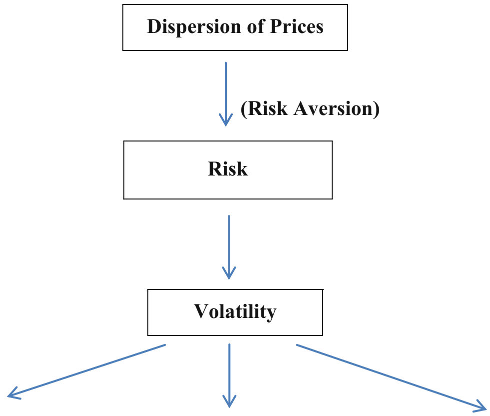
The motivation behind this ratio lies in the grounds of maximizing the utility by minimizing the risk and maximizing the expected return. The Sharpe ratio is a relative measure of return for a given risk level. The risk level is relative to a benchmark we are interested in. For example, when we use the market portfolio r_M as the benchmark $(r_b = r_M)$ then the Sharpe ratio reveals how much excess return is i asset providing a unit of excess risk.

4.2.3.2 Covariance

The covariance of an asset's price with a portfolio of interest does inform us about the attractiveness of such an investment. Being an investment, an asset's price contributes to the risk and return of a portfolio. If this asset's return is negatively related to that of the rest of the portfolio it provides diversification value to satisfy the risk aversion habits of the investors. Of course, we must choose on the benchmark relative to which the risk is being measured. For instance, if we are interested to know how risky the crude oil price is while we are holding a basket of stocks (for example the NYSE index), then we are looking for the comovement between crude oil prices and this particular index.

$$b = \frac{cov(r_i, r_M)}{var(r_M)} \tag{4.5}$$

Where:
r_i: is the return of the asset
r_M: is the return of the benchmark we are using
$cov(r_i, r_M)$: is the covariance between r_i *and* r_M
$var(r_M)$: is the variance of r_M

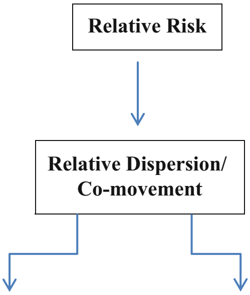


Standard deviation	GARCH(p,q)	Value-at-Risk
$\sigma = \sqrt{\frac{\sum x_i^2}{i} - (\frac{\sum_1^i x_i}{i})^2}$	$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2$	VaR= μ- $Z_{0.01}$ *SE
Standard deviation is the simplest and most widely used measure of price dispersion. If it is not treated with caution, a limitation of standard deviation is its association with normal distribution. Using higher moments (skewness and kurtosis) helps us evaluate the distribution more thoroughly.	GARCH follows a more sophisticated methodological procedure to describe the empirical characteristics of financial prices movements. It is very useful in forecasting the behavior of financial time series. However it lacks the simplicity of the standard deviation.	Value-at-risk is the level of maximum expected losses given a probability we have set beforehand. It can be estimated using different methodologies and assumptions; here we use the standard deviation method. It provides us with a single loss number in absolute terms.

Fig. 4.1 Dispersion of prices

4.2.4 Overview

In this section, we briefly discuss the risk measures, the different dimensions of risk they proxy, and strengths and weaknesses of each of them. In Fig. 4.1, we first start with the dispersion of prices generally considered as a risk for the investor who holds the asset. The risk aversion or uncertainty aversion of individuals dictates that price volatility is an unattractive feature. By using the dispersion of prices, we are able to construct several risk measures.



Risk-reward ratio –Sharpe	Covariance with Benchmark
$S = \frac{E(r_i - r_b)}{\sigma}$	$b = \frac{cov(r_i, r_M)}{var(r_M)}$
The Sharpe Ratio provides a relative index for comparing the risks and gains of different investments. Relating the average excess returns to a benchmark and the standard deviation of this excess return gives us a measure of "reward for given risk"	Covariance is frequently used in portfolio theory when we are interested in comparing how returns on one asset are related to those on another.

Fig. 4.2 Relative risk

In Fig. 4.1 we give an overview of three well-accepted risk measures. We give the definition and mention basic characteristics. Similarly, in Fig. 4.2, we present the "relative dispersion" measures instead of absolute price dispersion. These are the main dimensions in which to measure risk. Which dimension is most appropriate one depends on the purpose of the evaluation. If we want to construct a single simple and widely used measure – which is hopefully well-understood – we may use the standard deviation or Value at Risk. If we are interested in more precise forecasts of volatility, we may use a GARCH type of measurement. On the other hand, if we want to compare the risk of the specific asset to a particular benchmark, then the Sharpe ratio or the covariance of this asset in relation to a specific benchmark are the most appropriate risk measures.

4.3 Energy Assets

Many energy sources are being used for consumption. Electricity is the single most important final product consumed by most households, however to produce this electricity coal, oil, hydropower, wind or natural gas will have to be used (Capros et al. 2010). In this chapter we are interested in energy assets that can actually be traded in an exchange and their prices evolve in a market-based economy.

Since the liberalization of the electricity markets and the trading of electricity at power exchanges, electricity prices have experienced a very volatile pattern. The difference compared to other energy assets, which potentially makes electricity even more volatile, is amongst others its non-storable nature. Electricity cannot be stored in a direct way. This results in the fact that imbalances between electricity production and consumption can hugely impact on spot prices. These characteristics affect the volatility of electricity prices and make electricity a risky asset. Several authors try to describe the empirical features of energy prices. For example, Garcia et al. (2005) use GARCH to forecast day-ahead electricity prices in the Spanish and Californian markets. They suggest that weekend effects as well as exogenous (water storage, weather) variables might improve their model. Cuaresma et al. (2004) investigate the forecasting abilities of a number of univariate models on hourly electricity spot prices. Using Leipzig Power Exchange data they suggest the use of hour-by-hour modelling strategy with the use of price-spikes.

Crude oil prices have a much longer history of international trading than electricity. Due to its nature and early use, industries have been interested in the exploration, extraction and transportation of crude oil. Oil was the first energy sector to be liberalized and traded at a global level and has been researched extensively with regard to price modeling. Kang et al. (2009) forecast volatility for three crude oil markets with GARCH type models. Wei et al. (2010) use both West Texas Intermediate (WTI) and Brent oil prices and find that the non-linear GARCH has better predictive ability than the linear models. Cheong (2009), using the same oil prices, suggests that the two differ regarding their predictive features. Elder and Serletis (2008) examine the random walk behaviour of energy futures prices. Nomikos and Pouliasis (2011) find a regime changing pattern following fundamentals when investigating petroleum futures prices. While natural gas is an emerging market, there are studies attempting to model its pricing characteristics. Traditionally, natural gas pricing has been linked to crude oil prices. Pindyck (2003) finds that crude oil volatility and returns have predictive power for natural gas volatility and returns but not the opposite. Herbert (1995) finds that the volume of trading significantly affects volatility natural gas futures. Other studies investigate price dynamics using also weather or storage data (Mu 2007). With the advent of unconventional gas, it appears that gas prices increasingly depart from oil prices.

4.4 Data and Application

To illustrate the main energy risk measures, we have collected data from different sources. Electricity prices and volumes are from the European Energy Exchange (EEX henceforth), which resulted as a merger of two other power exchanges in Leipzig and Frankfurt, and the Nord Pool Spot Exchange operating in the Nordic markets.

Figure 4.3 plots the spot prices of electricity in Germany and Austria (Phelix) and Switzerland (Swissix), both traded at the EEX. We use observations from

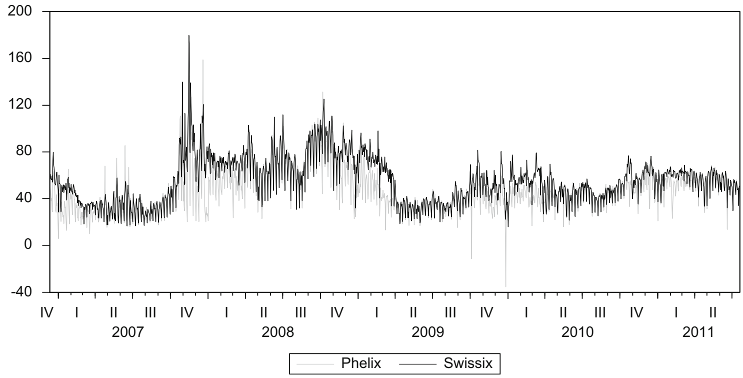


Fig. 4.3 Spot electricity prices in Germany-Austria (Phelix) and Switzerland (Swissix) in EUR/MWh

January 2007 to June 2011. Although they are neighboring markets and are being traded at the same exchange, they demonstrate quite different price behavior. To illustrate the first measure of price dispersion, Fig. 4.4 plots the rolling 2-month standard deviation of these (Phelix and Swissix) prices. Electricity has quite some particular characteristics and a time of the year effect. As we observe in Fig. 4.4 every winter there seems to be an increase in the volatility (standard deviation) of both electricity products. The increasing demand causes surges in electricity prices. As we discussed earlier electricity is a non-storable assets and hence demand increases is harder to accommodate.

As regards the natural gas market, there are two markets being traded at the EEX. We use GasPool which is connecting around 400 gas networks and covers about half of the German market. In Fig. 4.5, we plot the day-ahead spot prices of natural gas of GasPool for the period January 2010 to May 2011. We observe that during these 16 months natural gas has a steadily increasing price (more than 50 %) from 13 euros in early 2010 to 22 euros in May 2011. Figure 4.6 plots the rolling 2-month standard deviation for this data series. The data sample of GasPool extends from January 2010 to May 2011. This is limiting us the time span we are able to use for the respective risk measures. However, this 16 months of daily data still consists of 357 observations for natural gas and 365 for the crude oil. For crude oil we use the two most traded products, West Texas Intermediate (WTI) index and Brent. These products are widely considered to reflect oil prices. In Fig. 4.7, we plot the spot prices of crude oil prices of WTI for the same period as natural gas prices (i.e. January 2010 to May 2011). WTI has also an increasing trend of crude oil prices similarly with natural gas. This common trend is a first indication that natural gas and crude oil were still linked during the observed period. In Fig. 4.8, we plot the rolling 2 month standard deviation for WTI. For the time period January 2010 to May 2011 we use a GARCH (1, 1) to describe another way of measuring risk exposure. For demonstration reasons we only use a GARCH (1, 1)

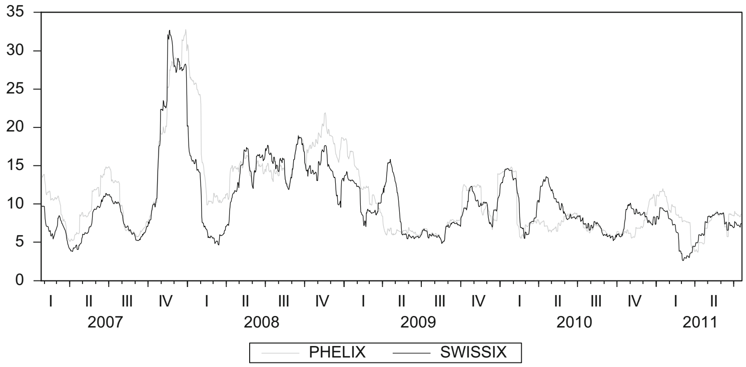


Fig. 4.4 Standard deviation of spot electricity prices

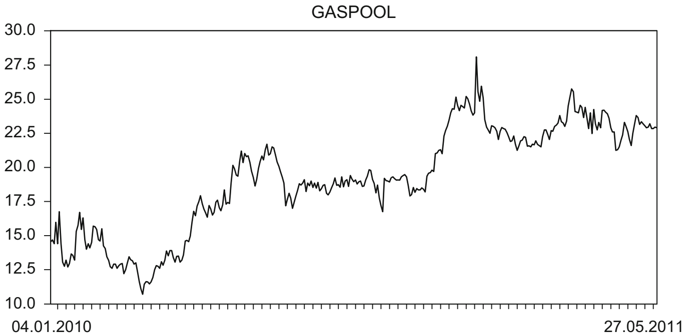


Fig. 4.5 Day-ahead natural gas prices in Germany in EUR/MWh

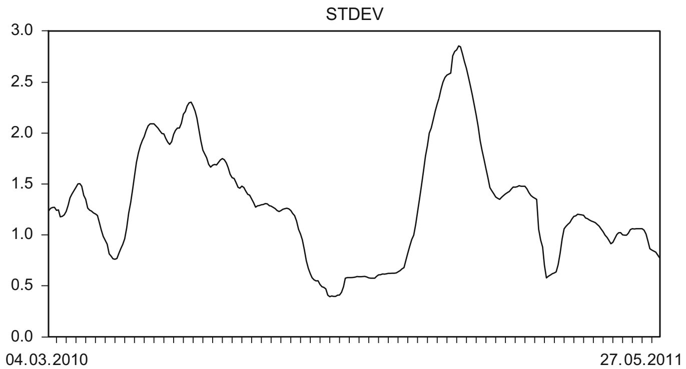


Fig. 4.6 Standard deviation of GasPool day-ahead prices

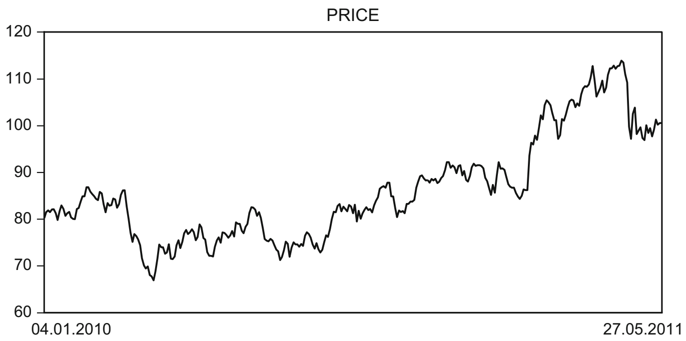


Fig. 4.7 WTI prices in U$/BBL (US dollars per oil barrel)

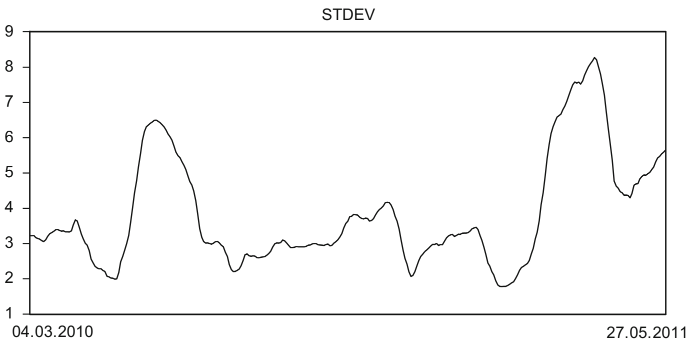


Fig. 4.8 Standard deviation of WTI

for the four energy assets. We take the returns of each series so we have a stationary sample. In Fig. 4.9, we plot the conditional variance for four energy assets from Panel a to Panel d.

4.5 Results

In the data section we described how we collected our data series. We have two electricity products, Phelix and Swissix, one natural gas product, GasPool, and two crude oil products, WTI and Brent. Table 4.1 provides a summary and the descriptives of these products prices. The average price for the two electricity assets during January 2010 – May 2011 is 46.97 EUR/MWh and 53.23 EUR/MWh for Phelix and Swissix respectively. For the same period, the average price of GasPool is 19.16 EUR/MWh. It is 85.06 U$/BBL(US dollar per oil barrel) for West Texas Intermediate, and 88.84 U$/BBL(US dollar per oil barrel) for Brent. For the electricity prices the median is larger than the mean price and for the crude oil products the opposite is the case. All energy products seem to observe very low

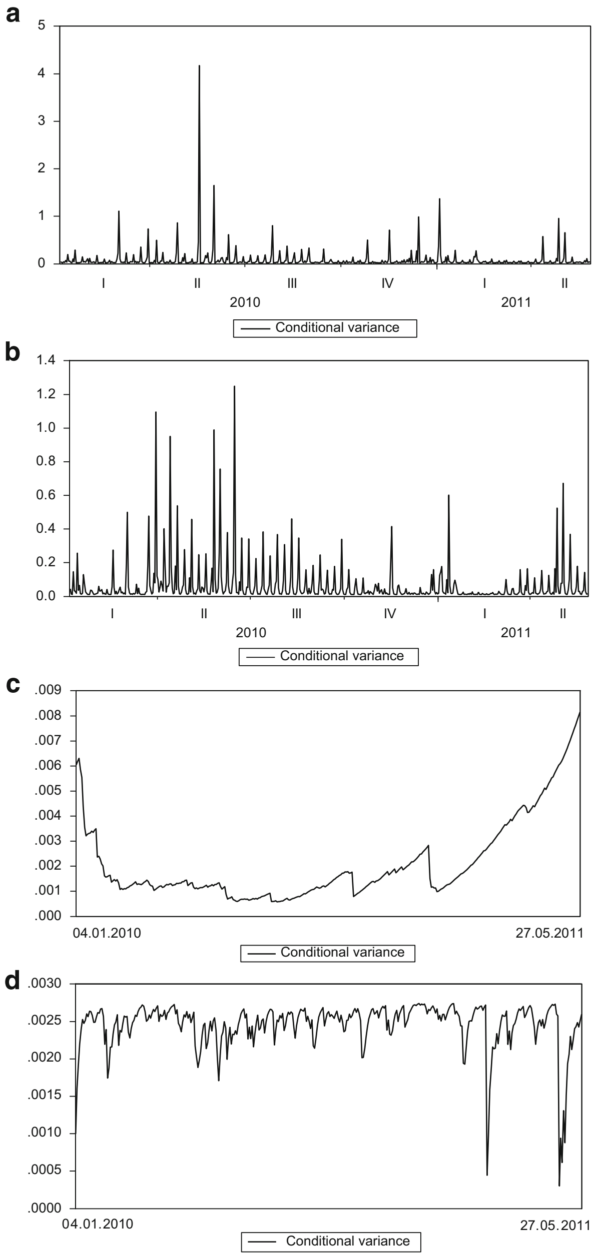


Fig. 4.9 GARCH. (Panel **a**): GARCH (1, 1) for Phelix returns. (Panel **b**): GARCH (1, 1) for Swissix returns. (Panel **c**): GARCH (1, 1) for GasPool returns. (Panel **d**) GARCH (1, 1) for WTI returns

minimum and high maximum prices indicating their volatile nature. Electricity (Phelix and Swissix) and Natural Gas (GasPool) are negatively skewed, while Crude Oil (Brent and WTI) products are positively skewed. This is also shown by the median being larger than the mean for Electricity and Natural Gas and the mean

Table 4.1 Descriptive statistics for the five energy assets

Energy asset	Electricity		Natural gas	Crude oil	
Product	Phelix	Swissix	GasPool	Brent	WTI
Mean	46.97	53.23	19.16	88.84	85.06
Median	47.44	54.77	19.15	83.07	82.37
Maximum	72.06	79.25	28.10	126.5	113.9
Minimum	15.94	21.37	10.70	67.37	66.88
Std. Dev.	9.307	10.46	3.815	15.82	10.87
Skewness	−0.343	−0.448	−0.326	0.948	0.941
Kurtosis	3.295	2.890	2.129	2.640	3.083
Observations	509	509	357	365	365

The time span of our sample is from January 2010 to May 2011. This is 509 daily observations for the electricity products, 357 for the natural gas, and 365 for the crude oil products

to be larger than the median for Crude Oil. As regards the fourth moment of these assets the picture is less clear as one Electricity (Phelix) and one Crude Oil (WTI) commodity are leptokurtic while all other three commodities (Swissix, GasPool and Brent) are platykurtic with less observations around the mean compared with the normal distribution.

In Table 4.2 we have structured the risk measures we use for the energy products. The first risk measure we apply is the standard deviation, and we report its estimation for the complete period January 2010 to May 2011. It is expected that products with higher price will have also higher standard deviation, which we can witness for all assets. WTI seems to have a smaller value of standard deviation given its higher average price. At the same time Brent has a much larger standard deviation than WTI even though these two are both crude oil products with very similar actual use. In order to estimate GARCH we first take the returns of the series to avoid non-stationarity problems. We cannot directly compare the results of the variance forecasted by the GARCH model and that of the standard deviation. First, this is because we are using prices for the standard deviation, whereas we use GARCH for forecasting the volatility of the energy assets' returns. With the standard deviation we typically assume that volatility is not time-varying and our forecast for the next period would be within a constant range. With GARCH modeling, we use every period's new returns to update our forecast and hence add a time varying feature which depends on last period's forecasted errors and predicted volatility (see Eq. 4.3). Even though we cannot directly compare the two measures, we notice that Phelix now seems to be more volatile than Swissix compared to the conclusions drawn from the standard deviation. This indicates that Phelix has a more persistent pattern (larger GARCH parameter) and Swissix has a larger unexpected part (larger error parameter, α_i in Eq. 4.3). In addition, it appears that the WTI and Brent crude oil is much less volatile than both Phelix and Swissix. However, they both are more volatile than GasPool. In the reported results for Value-at-Risk, we assume that we are particularly interested in the maximum one-day possible (at 99 % of the times) returns-loss given the standard normal

Table 4.2 Risk measures indicators for five energy assets

Energy asset	Electricity		Natural gas	Crude oil	
Product	Phelix	Swissix	GasPool	Brent	WTI
Price	46.97	53.23	19.16	88.84	85.06
Standard deviation	9.31	10.46	3.82	15.82	10.87
GARCH	0.082	0.065	0.0021	0.0032	0.0025
VaR (%)	−0.13	−0.42	−0.25	−0.09	−0.15
Sharpe	0.049	0.031	0.038	0.049	0.020
Covariance	0.147	−0.302	−0.202	0.709	0.865

The time span of our sample is 17 months, from January 2010 to May 2011. That is 509 daily observations for the electricity products, 357 for the natural gas, and 365 for the crude oil. For creating Sharpe and Covariance measures, we have matched the sample observations for all four assets, leaving us with 356 observations (one less due to taking returns instead of levels of prices)

distribution feature. In this respect, the least risky asset seems to be Brent (−0.09 % return) and the most risky Swissix (−0.42 % return). What is interesting here is that while Brent has roughly one and a half times the standard deviation of WTI, its Value at Risk is much smaller.

To create Sharpe-ratios, we have to adjust our sample for some occasions. NYSE trading is available only during weekdays from 9:30 a.m. to 4:00 p.m. ET and whether there is trade earlier or later for a particular stock does not differentiate the product (one stock of the company). On the other hand, electricity as a physical asset that cannot be stored has quite different characteristics. It is being traded on an hourly basis and has a time of the day effect, peak hours are much more costly than off-peak hours. There is a very informative discussion about this in Dorsman et al. (2013). At the same time NYSE is being traded only on weekdays and electricity also during the weekends. But to be able to construct some relative indexes of risk we must have a common periodicity of price observations. Hence, we use only weekdays on a daily basis for both electricity (same with natural gas and crude oil) and NYSE. To create Sharpe-ratios, we have deleted all observations that did not match for the same dates in order to arrive at a comparable sample. As such, we are left with 356 observations for which all products-indices were traded. The Sharpe-ratio, being a reward-to-risk relative index, enables us to directly compare the (relative) returns of the four energy assets. Using NYSE as a benchmark, Phelix and Brent turn out to be the most rewarding assets for a given level of risk. WTI on the other hand is the least rewarding even though its VaR showed to be quite low. If we compare the two crude oil assets, we would expect that since Brent has higher standard deviation (denominator of Sharpe) it may also have lower Sharpe ratio than WTI. However, Brent has higher returns (nominator in the Sharpe ratio) during this period which is also reflected by the increasing spread between Brent and WTI prices. Of course, we have to keep in mind that these different measures are applied for a narrow period of only 16 months.

Finally, the covariance measure is also a relative risk measure. Again we use NYSE index as our benchmark, and calculate the risk of holding energy assets compared to the index. A negative sign implies that when the NYSE index is increasing, the respective asset's price is decreasing. One Electricity asset (Swissix) and Natural Gas (GasPool) have negative covariance with NYSE. When the NYSE index increases, the prices of Swissix and GasPool tend to decrease, and vice versa. On the other hand Phelix, and the two Crude Oil products (Brent and WTI) have a positive covariance with the NYSE index. Especially Crude Oil seems to be very much closely related with the index and when NYSE increases by 1 %, WTI increases by 0.865 % and Brent by 0.709 %. Phelix is positively but not strongly correlated with NYSE.

Conclusions

Energy is a strategic commodity. Its availability and price conditions determine the production-consumption processes. Price fluctuations interact with demand-supply decisions and economic growth. In this chapter we discuss some tools to measure energy price risk. For many, risk is a generic concept and is widely regarded as an undesirable feature of everyday life. For others, though, it is the rationale for their economic existence. We discussed that it is not straightforward how risk exactly can be measured. Risk can be approximated by absolute percentages or by relative measures. Whether we are interested in price fluctuations, forecasting returns, approaching the potential loss of holding an asset, or the price variation compared to a benchmark, we can identify different dimensions of risk. In this chapter we have constructed five aspects of risk for five energy assets. We split the price fluctuations in two categories of risk, namely absolute and relative. Standard deviation, GARCH and Value at Risk provides us with an absolute number, while Sharpe ratio and Covariance provide us with a relative measure. The measures discussed describe different aspects of risk and each one has its own merits. Investors, consumers, or industries having energy as a crucial productive input may be interested in the fluctuations of energy prices and risks involved. Energy markets are spatially fragmented, and need extensive infrastructure investments to integrate geographical areas. This is even more complicated by the steady increase of renewable energy generation affecting prices of electricity (Sensfuss et al. 2007; Moreno et al. 2012). This highly volatile nature of energy prices is a challenge for both practitioners and academics. We intended to provide an overview of established risk measures in a way that would be easy and straightforward to be used when one has to account for energy price risk. The variety of risk dimensions has to be taken into account when deciding whether to invest in a project or an asset or on how to manage risk exposure.

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Part II

Geopolitical Risks

The Natural Gas Revolution and Central Asia

5

Robert W. Kolb

Abstract

This article examines the ongoing natural gas revolution and assesses its impact on the energy industry and societies of Central Asia, conceived as the five "Stans": Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. The natural gas revolution consists of three related technological developments—hydraulic fracturing, horizontal drilling, and the increasing build-out of the world liquid natural gas (LNG) infrastructure.

The article focuses on Turkmenistan and its rich reserves of natural gas and explores the conditions under which Turkmen gas currently reaches international markets through pipelines to China, Iran, and Russia. It also assesses Turkmenistan's future prospects for reaching additional world markets and for sustaining the markets it presently serves. Finally, the article analyzes the difficulties that Turkmenistan's gas industry, and other Central Asia energy industries, are likely to face.

5.1 Introduction

This paper assesses the impact of the so-called natural gas revolution on the countries of Central Asia, taken as the five "Stans" of the former Soviet Union—Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. The "natural

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gas revolution" refers to the sudden increase in available current supply, a dramatic fall in natural gas prices, and much enlarged estimates of world proven reserves of natural gas, developments that are due primarily to the development of new technologies. These new technologies include hydraulic fracturing, horizontal natural gas well drilling, and the maturation of the LNG (liquid natural gas) infrastructure. Natural gas produced using hydraulic fracturing and horizontal drilling is termed "unconventional gas" and contrasts with "conventional" natural gas accessed by individual wells that are purely vertical and that do not necessarily involve hydraulic fracturing.

These five nations are not active participants in the natural gas revolution. They drill conventional wells and generally do not utilize hydraulic fracturing or horizontal drilling. Also, they are far removed from open seas, which could allow them to ship their natural gas as LNG. Nonetheless, the natural gas market has increasingly become a world market, and the natural gas of Central Asia already competes in a market in which unconventional natural gas and LNG have an increasing role.

Section 5.2 of this article briefly reviews the essential elements of the natural gas revolution, including the technological and operational basics of hydraulic fracturing and horizontal drilling, the falling prices of natural gas, the development of LNG infrastructure, and the ecological risks associated with this new technology. Section 5.3, "Natural Gas and the Future of Central Asia," begins the central analysis of the paper by examining the production and reserves of each nation and the means by which each nation can hope to bring its gas to market. Because all five countries are landlocked, they must rely on pipeline transmission over long distances to reach lucrative markets such as China or western Europe. These nations of Central Asia are surrounded by other countries, some with their own rich reserves of natural gas, and all with their own economic and geopolitical ambitions, factors which have a strong effect on the ability of the "Stans" to capitalize on their very considerable energy resources.[1]

Of the five "Stans," Turkmenistan holds the largest natural gas reserves, and has the best prospects of delivering gas to a world market, and it will also be the country most affected by the natural gas revolution. Accordingly, Sect. 5.4, "Prospects for Turkmenistan's Natural Gas," focuses on this country particularly.

5.2 Essential Elements of the Natural Gas Revolution

As many commentators have noted, there is a current revolution in the world energy situation.[2] Others have spoken of the world's entering an "age of natural gas" or a "golden age of energy" (International Energy Agency 2011; Wolf 2012). Still

[1] For a review of the current energy geopolitical situation, see Kolb (2011).

[2] For example, a report by Citigroup speaks of the "shale gas revolution" and the death of the "peak oil hypothesis": Citigroup (2012). See also: Forbes (2012), Gas Strategies (2010), Stevens (2010), Yergin (2011).

others herald the emergence of the United States as a type of Saudi Arabia, or even a "Saudi America" of energy (Jaffe 2010, 2011; Moore 2011; Gjelten 2012; Milner 2012).

Over recent decades new drilling technologies has been developed and implemented, resulting in a dramatic increase in U.S. natural gas production: "hydraulic fracturing" and "horizontal drilling." In hydraulic fracturing, the older of the two techniques, an energy production firm drills a well into a reservoir containing gas or oil and carefully seals the well bore so that it can withstand pressurization. The driller then forces a combination of water, sand, and a mixture of chemicals through the well and into the surrounding rock. The pressure fractures the friable rock, allowing gas to percolate into the well and up to the well's collection point.

More recently, U.S. firms have succeeded in drilling horizontally through shale beds to reach more gas from a single surface well. In this process the driller sinks a vertical well, which may be a mile deep, to reach a gas-containing shale bed. At this point, the exploration company turns the drill sideways and continues to drill horizontally through the shale rock. When drilling stops, the driller removes the drill and introduces small holes into the well casing surrounded by the shale by igniting controlled explosions. With the holes in the well casing in place, the driller pumps fracturing fluid, a mix of water, sand, and chemicals, into the horizontal portion of the well, causing the shale bed to fracture and release gas back into the well. This process of horizontal drilling and hydraulic fracturing can be repeated from a single vertical well, thereby reducing the number of vertical wells required to exploit a gas field and reducing the drilling footprint at the earth's surface.

In the United States, natural gas produced by unconventional methods already exceeds that produced by older conventional methods, and the U.S. Energy Information Administration predicts that by 2035, unconventional gas will constitute fully 75 % of U.S. production (U.S. Energy Information Administration 2011a, p. 44). In the last three decades, U. S. natural gas production has increased by 50 % and reserves have almost doubled due largely to the advent of shale gas. Most strikingly, the U.S. Energy Information Administration notes that shale gas production surged from 0.39 trillion cubic feet in 2000 to 4.87 trillion cubic feet in 2010, jumping by a factor of more than twelve times in a single decade (U.S. Energy Information Administration 2011b, p. 1). The changing supply and production levels have had profound consequences for prices. After peaking in 2008, prices for natural gas fell by 80 % and have recovered to less than 40 % of the 2008 maximum. Over this period, the price of crude oil has remained high, so the cost per unit of energy in the form of natural gas has become quite inexpensive compared to that of oil.

While the natural gas revolution has thus far been primarily a U.S. development, other nations are changing that very rapidly, as many other nations possess their own shale gas resources. In an initial assessment, the U.S. Energy Information Administration concluded that ". . .the international shale gas resource base is vast," (U.S. Energy Information Administration 2011b, p. 2) even though the report assessed only 32 countries outside the U.S. and excluded Russia, Central Asia, the Middle East, South East Asia and Central Africa from the analysis. The study found tremendous resources in every continent except Antarctica, with apparently very large deposits in Canada, South America, South Africa, the Maghreb, Europe, China, and Australia. Very active efforts are underway in many of these areas to develop the necessary technology and to exploit these newly discovered gas reserves. For instance, China has actively been acquiring some U.S. firms with hydraulic fracturing and horizontal drilling expertise and has been partnering with other such firms.

Beyond the techniques of hydraulic fracturing and horizontal drilling, a third critical element that features in the natural gas revolution is the build-out of the LNG (liquid natural gas) infrastructure and market. Natural gas can move from a gas field to elsewhere in three main ways: via pipeline, via compression and transport by rail or truck, or via liquefaction and transport by ship.[3] Of these three, pipeline transmission is cheapest in the normal event. Compression is not scalable, because compressing reduces the volume of natural gas by a factor of only about 100, leaving road or rail transport prohibitively expensive.[4] LNG technology is not new, but the rapid development of an ever expanding LNG infrastructure constitutes an important part of the story of natural gas. Liquefaction reduces the volume of natural gas by a factor of 600, allowing transport by ship.

Building pipelines from natural gas fields to markets is ruinously expensive, and most pipeline developments can proceed only with an assured market for the natural gas. Thus, pipeline contracts have typically called for gas purchasers to enter long-term contracts for natural gas with gas prices linked to oil. With current low natural gas prices, the contract price for many of these pipeline-delivered supplies costs five to eight times as much as the current spot price of natural gas in world markets.

Because so much of the world's natural gas production and delivery system has been governed by these pipeline contracts, a world market for natural gas has been slow to develop. That is now rapidly changing with enormous implications. Three countries illustrate the power of these developments. Qatar has very rich gas resources, but with its location in the Persian Gulf, it is a long way from markets. However, it has become a very robust LNG supplier, with immediate access through the Straits of Hormuz to the open sea. For its part, Japan almost totally lacks hydrocarbon deposits. In the wake of the March 2011 Fukushima nuclear disaster Japan shuttered its nuclear plants, making it ever more dependent on the delivery of overseas oil and natural gas. For its part, Australia now suddenly

[3] Of course, LNG can move by truck or rail as well, but those quantities are much more limited than seaborne transit. Also, in addition to being liquefied, natural gas can merely be compressed and shipped by rail, truck or ship. However, compression reduces the volume of natural gas by only about a factor of 100, while liquefaction allows reduction by a factor of 600.

[4] Compressed natural gas does have an important role to play. If gas can be piped to a facility and compressed there, the compressed gas can be used as a fuel for vehicles. This is already being done. However, compressing gas and moving it by rail or truck as a substitute for pipeline gas or LNG is not feasible due to costs.

appears to be poised to be a major LNG supplier, further enriching the world supply of gas and strengthening the movement toward a genuinely world market.

The price of LNG by long-term contract has typically been much greater than the spot market price of gas. Part of this differential can be attributed to the higher cost of LNG delivery. To liquefy gas requires a very expensive liquefaction plant that can chill the gas to its liquefaction point of −260 °F. Then the liquefied gas must be transported by ship, which costs considerably more than pipeline transmission. However, much of the excess cost of LNG over the spot market price exceeds the actual cost of liquefaction and delivery. With a burgeoning LNG infrastructure and a number of new suppliers in the market, one can reasonably expect the price of LNG-delivered gas to fall toward the spot market price plus the added cost of liquefaction and transport. This will be an enormous benefit to countries such as Japan.

Further, the development of a robust LNG market gives many nations a choice of using LNG or pipeline-delivered gas. For example, India has an extensive coastline and can receive LNG quite readily. If gas must be delivered by pipeline over a very long distance, over very rugged terrain, and across many national boundaries, with each transit country imposing a fee, the price differential between LNG and pipeline gas can be seriously eroded or even erased. Thus, the natural gas revolution holds out the promise to radically expand worldwide supplies, to allow many nations to develop domestic resources that were previously thought inaccessible, and to facilitate a worldwide market in natural gas through an improved and elaborated LNG infrastructure.

However, potentially devastating environmental consequences associated with the technique of hydraulic fracturing lie at the heart of the natural gas revolution. First, the chemicals used in the fracturing fluid might leak into aquifers and cause serious water contamination. Second, hydraulic fracturing might cause earthquakes, and there is some evidence that this has occurred already.[5] Third, hydraulic fracturing requires water, usually 2–4 million gallons per well. Clearly, using water for gas-drilling competes with other potential uses. However, hydraulic fracturing advocates point out that even in very dry climes, the fraction of water devoted to gas drilling is really quite small. Fourth, natural gas drilling creates disruption at the surface, including scarring of the land, unsightly drilling rigs, and the introduction of heavy vehicle traffic into rural areas. In addition, when the drillers enter a region the riches it brings to some, but only some, local residents, may alter the culture of areas that suddenly become targets of a gas boom.[6] With so much at stake—wealth, access to energy, the future of the world's energy mix, and the environment, including the entire question of hydrocarbons and global climate

[5] Also, most of the water used to fracture shale returns to the surface through the well and must face disposal. One longstanding means of disposal has been to inject the used water into old hydrocarbon reservoirs, and now evidence indicates that this too can cause minor earthquakes.

[6] For example, see McGraw (2011). McGraw's book features a personal perspective on the impact of the shale gas revolution on his home town in the Marcellus Shale region of Pennsylvania.

change—much of the environmental debate surrounding hydraulic fracturing has become highly politicized with heavy sparring and self-serving analyses being offered by both industry lobbying interests and environmental pressure groups.

5.3 Natural Gas and Central Asia

While the five “Stans” possess rich resources of oil and natural gas, there are important differences among them. Further, as a group, they occupy a difficult geographical position, distant from any ocean and surrounded by powerful neighbors, many of which are also well endowed with petroleum and gas resources. Figure 5.1 shows the geographical position of these “Stans” and their nearby neighbors. To reach any large world market, gas from Central Asia must transit one or more countries, in some cases one or more of the other “Stans.” Thus, their geographical position creates many problems and offers very few advantages.

Table 5.1 shows key oil and gas statistics for Central Asia. Turkmenistan and Kazakhstan dominate the energy picture, with Turkmenistan leading in natural gas reserves and Kazakhstan dominating in oil. Kyrgyzstan and Tajikistan have minimal gas reserves. In spite of its more modest reserves, Uzbekistan produces considerable natural gas, yet consumes most of it, and remains a net importer of oil. As this paper focuses on natural gas, it will also focus on Turkmenistan, although Kazakhstan faces many of the same difficulties in reaching markets for its ample supplies of oil.

Taken together, these five countries have about the same total population as France, roughly 60–65 million, but with almost eight times the land area. The “Stans” are thinly populated, with only about 16 inhabitants per square kilometer, compared with France’s 114. Richly endowed with energy, but with a small population and large distances to cover, the energy problem for the five countries taken as a group is not acquiring sufficient energy for their own needs, but, rather, getting the gas and oil that they can produce to markets.

As we have seen, the two realistically possible methods for gas transmission are via pipeline and LNG. For Turkmenistan, LNG is completely out of the question, as the country is completely landlocked, leaving pipeline delivery as Turkmenistan’s only option for reaching world markets. Table 5.2 shows the various routes by which Turkmenistan might seek to get its gas to markets outside the immediate region. The list in this table is extremely inclusive, including some avenues that Turkmenistan currently exploits, some routes that are actually proposed and are currently being seriously considered, and even some rather fanciful and impractical routes as discussed below.

Turkmenistan’s gas, from which it currently supplies existing routes and hopes to supply future routes, lies in more than 1,000 gas fields, most of which remain untapped. Currently, the most important and apparently largest fields lie in the eastern portion of the country in the Amu Darya basin. Until very recently Turkmenistan drew its gas mainly from the Dauletabad and associated fields lying in the southeastern corner of the country, as Fig. 5.2 shows. This massive

Fig. 5.1 Central Asia and surrounding countries

Table 5.1 Oil and natural gas statistics for selected countries

	Production	Consumption	Exports	Imports	Proved reserves
Oil (millions of barrels)					
Kazakhstan	586.92	79.57	507.35	34.47	30,000.00
Kyrgyzstan	0.35	5.84	0.75	5.82	40.00
Tajikistan	0.08	14.60	0.15	14.38	12.00
Turkmenistan	78.84	45.63	35.56	0.00	600.00
Uzbekistan	31.76	37.96	0.76	3.29	594.00
Natural gas (billion cubic meters)					
Kazakhstan	20.20	10.20	8.10	3.70	2,407.00
Kyrgyzstan	0.02	0.67	0.00	0.64	5.66
Tajikistan	0.04	0.23	0.00	0.19	5.66
Turkmenistan	42.40	22.60	18.00	0.00	7,504.00
Uzbekistan	59.10	45.50	15.20	0.00	1,841.00

Source: CIA, *World Factbook*. Accessed: April 2, 2012. These data are constantly revised and show the latest information for each country, so that the figures being reported may not be drawn from exactly the same dates

field has largely supplied Turkmenistan's domestic consumption and furnished its exports. In 2006, Turkmenistan discovered the South Yolotan field and the associated Yashlar, Minara, and Osman fields. The South-Yolotan field lies nearby, about 70 miles southeast of the ancient oasis city of Merv on the Silk Road, near the modern town of Mary and somewhat north of the older Dauletabad field. An independent audit of its reserves places the new field as one of the largest, perhaps the second largest, field in the world, with reserves about five times as large as the already enormous Dauletabad field (Orazgylyjow 2009). Thus, while Turkmenistan

Table 5.2 Turkmenistan's gas delivery routes: actual and theoretical

From Turkmenistan to:	Type of destination	Associated pipeline
Kazakhstan to Russia to Western Europe	Ultimate market	Operational Central Asia-Center (CAC) pipelines; Proposed Pre-Caspian pipeline
Iran	Ultimate market	Operational Korpeje-Kordkuy pipeline; operational Dauletabad-Sarakhs-Khangiran pipeline
Iran to the Persian Gulf	Open sea and world market	None imminent or under active consideration
Russia (via the Caspian Sea) to Western Europe	Ultimate market	None imminent or under active consideration
Azerbaijan (via the Caspian Sea) to Georgia to the Black Sea	Open sea and world market	Proposed Trans-Caspian pipeline
Azerbaijan (via the Caspian Sea) to Armenia to Turkey to the Black Sea	Open sea and world market	Proposed Trans-Caspian pipeline
Azerbaijan (via the Caspian Sea) to Armenia to Turkey to the Mediterranean Sea	Open sea and world market	Proposed Trans-Caspian pipeline
Afghanistan to Pakistan	Ultimate market	Proposed Turkmenistan-Afghanistan-Pakistan-India pipeline (TAPI)
Afghanistan to Pakistan to India	Ultimate market	Proposed Turkmenistan-Afghanistan-Pakistan-India pipeline (TAPI)
Uzbekistan to Tajikistan to China	Ultimate market	Operational Central Asia-China pipelines
Kyrgyzstan to China	Ultimate market	None imminent or under active consideration

possesses an incredibly rich endowment of natural gas, it confronts the problem of getting that gas to world markets.

As Table 5.2 indicates, Turkmenistan has four international pipeline routes in current operation, two that serve northern Iran, one that reaches Russia (and from there the rich markets of western Europe through the Gazprom pipeline system), and one that delivers gas to China, with two operating pipelines and a third being constructed. Table 5.3 shows gas exports and their destinations for the three gas-exporting Central Asian nations, Kazakhstan, Uzbekistan, and Turkmenistan. Turkmenistan accounts for about two-thirds of the total and delivers to three destination nations, while all gas exports from Kazakhstan and Uzbekistan supply Russia and its pipeline network. Looking to the future, Turkmenistan's gas reserves are almost twice as large as those of Kazakhstan and Uzbekistan combined, with Kyrgyzstan and Tajikistan each holding only minimal gas reserves. As Table 5.1 shows, Uzbekistan currently out-produces Turkmenistan in natural gas, but its domestic needs consume much of its production. Turkmenistan, with its small population and large gas reserves, will become the ever more dominant gas exporter

Fig. 5.2 Turkmenistan's currently operational and proposed gas pipelines

among these Central Asian nations—if it can get its gas to markets. For these reasons, the pipeline network of Turkmenistan, including those lines that are already operational as well as those that are anticipated, remains the key.

While these central Asian nations were formerly part of the Soviet Union all of their gas exports flowed north to Russia and on to the other republics of the Union, with some reaching western Europe. Upon dissolution of the Soviet Union and the gaining of independence by former Soviet republics, the energy-rich countries of Central Asia faced a very serious problem. The existing pipeline infrastructure gave them only one potential customer, the now separate and not very friendly Russia and its state-owned energy megalith, Gazprom. Thus, the legacy pipeline routes from the Soviet era gave Gazprom a monopsonistic position. Recent decades have seen a struggle by the energy exporters of Central Asia to develop new markets, with Russia attempting to frustrate those efforts at every turn. Focusing on Turkmenistan's efforts to reach other markets with its gas is a continuing central plot line of this drama, but Kazakhstan, with its oil, confronts a set of problems similar to those that Turkmenistan faces with its gas.

Figure 5.2 shows Turkmenistan's current operational and proposed international pipelines. Until just recently, the most important of these was the legacy pipeline that delivers Turkmen gas to Russia, the Central Asia-Center (CAC) pipeline. Actually consisting of two branches that originate in the west and east of Turkmenistan, the pipelines run north, reunite in Kazakhstan, and then go on to Russia. The main thread of the CAC pipeline originates in the massive Dauletabad field (U. S. Energy Information Administration 2012b). The Soviets built the CAC system over many years from 1960 to 1988. Like virtually all transportation links and infrastructure connections in the outlying Soviet republics, the energy pipelines

Table 5.3 Gas exports of Central Asian nations beyond Central Asia, 2011 (billion cubic meters per year)

	From:			
	Kazakhstan	Uzbekistan	Turkmenistan	Totals
Russia	11.45	7.15	10.14	28.74
China	0	0	14.25	14.25
Iran	0	0	10.20	10.20
Totals	11.45	7.15	34.59	53.19

Source: British Petroleum (2011)

of Central Asia have a Russo-centric focus and organization (See Olcott 2004, especially p. 24). Upon dissolution of the Soviet Union, the ownership of gas pipelines in Russia passed to Gazprom. With the CAC pipeline as an independent Turkmenistan's only connection to the outside world, Gazprom's control of the Russian portion of the pipeline network effectively cut off Turkmen gas exports to Europe, or at least made them subject to Gazprom's whim. Not surprisingly, Turkmenistan found it necessary to sharply discount the value of its gas to its sole purchaser. A further problem with the CAC pipeline and Russian control is the inadequacy of the pipeline compared to Turkmenistan's massive gas reserves (Chow and Hendrix 2010; Fishelson 2007). Since Turkmenistan's independence in 1991, the history of its energy industry has been dominated by the search for outlet markets other than those controlled by Russia.[7]

In 1997 Turkmenistan connected a pipeline to Iran, the Korpezhe Kurt-Kui (KKK) pipeline, running 120 miles from Korpezhe, Turkmenistan to Kurt-Kui, Iran, where it connects with the Iranian pipeline system. To build this pipeline, Iran granted assistance to Turkmenistan, which repays this investment with 35 % of the gas delivered through the pipeline for a 25-year period (U. S. Energy Information Administration 2012b). Ironically, as discussed in greater detail below, Iran has the world's second largest gas reserves, but Iran has energy difficulties of its own that induce it to import gas from a country with a smaller reserve base. To that end, Turkmenistan completed a second pipeline to Iran in 2010, the Dauletabad-Khangiran line, also known as the Dauletabad-Sarakhs-Khangiran pipeline. This relatively short pipeline runs about 115 miles to connect to the Iranian national pipeline system. Both of these Turkmenistan-Iran pipelines mainly serve Iranian natural gas needs in the north of the country.

Also completed in 2010 was a much more ambitious and important pipeline originating in Turkmenistan and ultimately reaching Horgos, China, in the Xinjiang region, after transiting Uzbekistan and Kazakhstan, where it skirts the northern

[7] Russia is also promoting other avenues by which Turkmen gas could be directed north to its Gazprom pipeline network. Notably, Russia is pushing for the Pre-Caspian pipeline, which would originate in Turkmenbashi on the eastern shore of the Caspian, run north along the shore, transit Kazakhstan, and terminate in Russia. If Russia could capture Turkmen gas through this means, it would help to frustrate the development of the so-called "Southern Corridor" aimed at getting Central Asian gas to Europe and world markets without falling under Russian control. For a discussion of this Pre-Caspian project, see: Chow and Hendrix (2010), Gazprom (no date), and Simonov (2010).

border of Kyrgyzstan. This Central Asia-China dual pipeline is 1,150 miles long and required only a virtually unbelievable 18 months to construct.[8] The pipeline is scheduled to deliver 30 billion cubic meters per year for 30 years.

To the present, these pipeline routes from Turkmenistan—the CAC to Russia, the two small pipelines to Iran, and the Central Asia-China line—constitute the entire means by which Turkmenistan's natural gas reaches markets beyond its border. As Table 5.3 shows, about 30 % of Turkmenistan's gas exports go to Russia, 30 % to Iran, and 40 % to China, a proportion which has expanded enormously in just one year from 2010 to 2011. Turkmenistan's natural gas reserves can support even much larger exports. Yet only the four pipeline routes discussed above are actually operational. While many others are planned, only a domestic Turkmen pipeline, the East–west pipeline, is under construction. In essence, the East–west line will connect the rich gas fields of Turkmenistan's east to the Caspian littoral. There the East–west line can connect with an existing pipeline that runs to the north to supply the CAC pipeline. However, the ultimate goal is for this East–west line to be part of a system that will take Turkmen gas to the world in general and the hungry markets of Europe in particular (See Socor 2010).

Reaching those markets requires transiting the Caspian Sea, and Turkmenistan needs the projected Trans-Caspian pipeline to reach Azerbaijan, most likely at Baku. As Table 5.2 shows, once Turkmen gas reaches Azerbaijan, it could then reach the west. The key difficulty is actually transporting the gas across the Caspian to Azerbaijan, and the impediments to accomplishing this goal are very serious.

For Turkmenistan, the ultimate export prize is reaching the markets of Europe. Europe remains anxious to reduce its heavy reliance on Russia for its natural gas supplies and desires to open a "Southern Corridor" to bring gas and oil from the Caspian and Central Asian regions to Europe. Russia seeks to maintain its dominance as Europe's chief supplier and it is working hard to bring its South Stream pipeline to fruition. This route would originate in Russian territory on the Black Sea, cross the Black Sea to Bulgaria, and then proceed northward through the Balkans to western Europe. The chief competitor route has been the Nabucco pipeline which would originate in the non-Russian area of the Caspian region, run the length of Turkey, cross into Europe near Cape Helles, continue through Bulgaria, transit Hungary, and finally terminate in Baumgarten, Austria, a main hub in a western Europe gas pipeline network. In spite of years of planning and Europe's strong geopolitical need to both secure additional gas supplies and to diversify its sourcing, not a single foot of the pipeline has been built.[9] These alternative plans remain highly contested and the ultimate outcome remains far from evident.

[8] The time from groundbreaking to completion was 28 months with the construction started in July 2008 and finishing in December 2009. See CNPC (2009). The second of the dual lines was completed in late 2010.

[9] For a discussion of the Nabucco pipeline plan and the aspirations for a Southern Corridor, see: Bahgat (2009), Chow and Hendrix (2010), Pflüger (2012), Paillard (2010) and Terterov et al. (2010).

All of the plans and their attendant difficulties associated with Southern Corridor routes do little or nothing for Turkmenistan unless it can solve the problem of getting gas across the Caspian Sea. Establishing the Trans-Caspian pipeline, or some similar route, remains a necessary first step. Russia seeks to frustrate the Trans-Caspian project by pressing two objections to a gas pipeline from Turkmenistan to Azerbaijan. First, Russia and Iran urge that it is environmentally dangerous, claiming that the Caspian Sea is environmentally sensitive. This environmental handwringing serves mainly as a tactic for frustrating the Trans-Caspian line, rather than expressing a genuine ecological concern.[10] A second major, and more serious, difficulty with a Trans-Caspian pipeline stems from an issue regarding the "law of the sea" and depends on whether the Caspian Sea is legally a "Sea" or a "lake." If the Caspian is an inland lake, as Russia and Iran insist, it would be subject to joint governance by all five littoral states. If the Caspian is legally a sea, then it should be subject to the 1982 United Nations Convention on the Law of the Sea, and it should be shared out to the five littoral states for sovereign control of a portion by each nation.[11]

Russia and Iran want to insist on shared governance to block exploitation of the Caspian energy resources and to frustrate the laying of a Trans-Caspian pipeline. By contrast, if each nation controls its own sectors, Turkmenistan and Azerbaijan could cooperate to lay the Trans-Caspian pipeline transiting only their portions of the Caspian. With such continuing legal uncertainty and geopolitical strife, the parties have been reluctant to start building the pipeline, so the project remains dormant. By contrast, Azerbaijan has simply gone forward to develop its own Shah Deniz field just off Baku in the Caspian, which is currently producing and is under active further development (U. S. Energy Information Administration 2012a). For Turkmenistan, the present situation leaves it unable to export gas to the west and incapable of reaching European or other world markets.

Turkmenistan is also exploring other outlets to the east. Here the major proposed pipeline is the Turkmenistan-Afghanistan-Pakistan-India (TAPI) pipeline. Again, not a single foot of pipeline has been laid, and there are several somewhat different proposed routes for reaching India. Merely to reach the border between Pakistan and India would require a pipeline of about 1,000 miles (U. S. Energy Information Administration 2012b). In addition to the distance, the terrain is very difficult, and the internal political situation of both Afghanistan and Pakistan is precarious, to say nothing of persistent severe tensions between Pakistan and India. Nonetheless,

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[10] For a discussion of the putative environmental problems with a Trans-Caspian pipeline see Pflüger (2012). The following articles discuss the Blue Stream pipeline: Schaffer (2008), Tsereteli (2005) and Terterov et al. (2010). For analyses of the Nord Stream pipeline, see: Ghaleb (2011) and Lagutina (2011).

[11] For three treatments of these issues see: Amineh and Houweling (2007), Ipek (2009) and Zeinolabedin et al. (2011).

plans are proceeding with agreements signed by all four countries in 2010, followed by an agreement between Turkmenistan and Pakistan over import prices.[12]

5.4 Prospects for Turkmenistan's Natural Gas

Current outlets absorb only a small proportion of Turkmenistan's desired production and make only a small dent in its massive gas reserves. Turkmenistan delivers only small quantities of gas to Iran and has little prospect of expanding these deliveries significantly. With its huge reserves, one cannot imagine that Iran will import huge quantities of gas while its own resources continue to lie fallow. The very fact of Iran's large reserves helps to keep Turkmenistan's gas from finding outlets to the south. If Iran could export large quantities of gas, it would be more likely to sell its own production, whether delivered by pipeline eastward to Pakistan and India, or northward and westward toward Europe. Alternatively, a post-sanction Iran might deliver gas to world markets by transporting LNG overseas. There would be little point in Turkmen gas passing through Iran to reach other nations: Turkmenistan has its own direct routes to the east, and presently gas cannot flow out of Iran to the west due to continuing international sanctions. However, even if Iran were willing and capable of serving as a transit country for Turkmen gas, it would collect significant transit fees that might impair the competitiveness of Turkmen gas exports once they reached world markets.

Russia stands perfectly willing to receive Turkmen gas, but to reach Russia, pipelines gas must pass through Kazakhstan, or both Uzbekistan and Kazakhstan, both routes requiring the payment of transit fees. Also, Russia has proved a less than ideal business partner for Turkmenistan. Starting in 2009 Russia substantially curtailed its demand for Turkmen gas due to the worldwide recession and in spite of a standing agreement with Turkmenistan. After Russia closed a pipeline valve, an explosion occurred in April 2009. This led to a worsening of relations, and Turkmenistan's production and its deliveries to Russia fell substantially (Hamm et al. no date, See p. 31). The two countries have since resumed a more normal level, but this experience signaled the lack of reliability of Russia as a taker of Turkmen gas. While Turkmenistan will continue to deliver gas to Russia, Russia mainly desires discounted gas it can resell to Europe, which makes Russia a much less than desirable partner for Turkmenistan.

By contrast, China presently acts as a quite reliable customer for Turkmen gas, but gas delivered to China through the Central Asia-China pipeline has to face transit fees from both Uzbekistan and Kazakhstan. There is a further potential problem for long-term expanded deliveries to China as well—the prospect of China's exploiting its own shale gas deposits. China's shale resources are about

[12] U. S. Energy Information Administration (2012b). For further analyses of the prospect of the TAPI pipeline, see: Gawdat Bahgat (2009). Cohen et al. (2008), Foster (2010), Lall (2010) and Lin (2011).

50 % larger than those of the United States. Given the speed of Chinese development in other areas, one must expect China to develop its shale resources very rapidly. If China can replicate the success of the United States in exploiting shale gas, it may not need much Turkmen gas. Thus, Turkmenistan's present gas customers collectively leave much to be desired.

Turkmenistan's two other prospective routes are also quite problematic. The Trans-Caspian pipeline has little prospect of being built and becoming operational any time soon. Aside from the frustrations of international law and ecological complaints impeding construction, Azerbaijan has little incentive to speed a trans-Caspian pipeline. After all, it possesses its own very substantial gas reserves that are already in the market and being rapidly enlarged. As a consequence, Azerbaijan almost certainly prefers to sell its own gas westward, rather than to collect transit fees from Turkmenistan. Thus, the very presence of large reserves in Azerbaijan acts as an impediment to the deliveries of Turkmen gas across the Caspian. Further, the development of shale resources to the west of Azerbaijan, remains a factor that may affect the demand for Azeri gas supplies, with even greater negative effects on the demand for Turkmen gas.

In spite of much talking and signing of agreements, the TAPI pipeline remains a fanciful project. Beyond the great cost of constructing such a pipeline, it is hard to imagine investors coming forward to enter the geopolitical tangle that Turkmenistan, Afghanistan, Pakistan, and India collectively represent.

However, there may be even worse problems for expanding Turkmenistan's gas exports beyond its less than desirable present partners and its dismal prospects of laying new pipelines to reach distant markets. The rapid development of shale resources around the world has already caused natural gas price to plunge temporarily below $2.00 per 1,000 cubic feet. Many nations are striving to develop their own shale resources, including, Argentina, Bulgaria, Canada, China, India, Mexico, Poland, Ukraine, and the United Kingdom. As the very initial assessment by the Energy Information Administration indicates, the world's natural gas resources are at least 40 % larger than previously believed due to the inclusion of just some of the world's shale gas resources (U.S. Energy Information Administration 2011a, See p. 3). The widespread realization of the natural gas revolution holds the promise of making many nations much more self-reliant for their natural gas needs. Such a world likely would make expensive and difficult-to-access natural gas resources, such as those of Turkmenistan, too costly to exploit. In the face of such ample local production around the world, Turkmen gas might face a world without a market for its necessarily expensive gas.

Of course, even in a world fully characterized by a mature natural gas revolution, there will still be surplus and deficit nations. Japan, for instance, with its impoverished domestic energy resources will almost certainly continue to be a major LNG importer. South Korea will also be a significant natural gas importer, so long as potential land-based energy pipelines cannot transit North Korea.

Meanwhile countries such as Qatar are already very well placed to deliver LNG to deficit countries, again forestalling the world's need to access Turkmen gas. In short, if the promise of the natural gas revolution reaches fruition, Central Asia in general, and Turkmenistan in particular, will likely find that the world has little need to pay the price of securing their distant and hard-to-reach natural gas resources.

Given the arid climate, poor soil, and geographical isolation of the countries of Central Asia, one might expect the rich energy resources of the region in general, and of Turkmenistan, Kazakhstan, and even Uzbekistan, to provide the best opportunity for raising the standard of living and conditions of life. Of course, there is always the potential problem of a "resource curse" if a nation relies too heavily on extraction of a single type of resource. And there is certainly a great need to address problems of a social nature in these countries, as poverty is rife, the agricultural sector is large and inefficient, corruption is rampant, freedom is constricted, and the rule of law is insecure to non-existent. Intelligent development of their energy endowments might provide the resources to address these problems if they could be beneficially allocated. Such enrichment would be only a necessary condition, with sufficiency being attainable only by resolving endemic governance problems in the region.

The developed world has a stake in Central Asia as a major entrepôt and drug-producing region. Further, depressed social circumstances, such as those that characterize Central Asia presently, coupled with the rise of militant Islam, provide an ideal breeding ground for anti-Western terrorists. Economic development is the best hope for curing these problems, and the best hope for economic development in the region lies in the energy sector. Nonetheless, as this paper has argued it will be quite difficult for these Central Asian nations to capitalize on their energy riches, due to long distances to international markets, routes to these markets that must transit nations with their own competing energy resources, or routes through politically unstable states. Further, even if Central Asian natural gas reaches world markets, these nations may find a market characterized by already rich endowments from widely scattered local sources with prevailing prices for natural gas that make Central Asian gas uncompetitive.

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The Influence of Economic, Financial and Political Indicators in South East Asian Electricity Markets

6

John Simpson

Abstract
Dynamic models of electricity pricing in South East Asian countries are studied in this chapter. The motivation is to attempt to explain the extent of regulation in South East Asian electricity markets using political, economic and financial indicators as reflected in risk ratings and energy stock market sectoral data. Electricity market models in China, Thailand and the Philippines show evidence of cointegration, implying relative market efficiency and deregulation in those countries in the long-term. Those in Malaysia and Hong Kong are not cointegrated implying that electricity pricing in those countries has little to do with domestic and international financial, economic factors over the long-term. This in turn indicates significant government pricing interference in the case of Malaysia and domestic share market influences in the case of Hong Kong. In their demonstration of long-run equilibrium and short-run exogeneity effects, the specified models of can be useful in studies of electricity market deregulation. The results may be useful as a starting point to analyse long-term and short-term electricity pricing policy.

6.1 Introduction and Background

The motivation for this study is to further explain global, domestic, economic and financial and political influences on electricity pricing in South East Asian countries. South East Asian countries have been selected on the basis that the region is globally the strongest in terms of population growth, GDP growth and in the growth of demand for energy and electricity. The sample is representative of

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South East Asian countries, which are predominantly developing or transitional economies. Singapore is excluded from the sample as it does not fall into the latter categories. The countries selected in the sample are those that simultaneously quote electricity prices as well as oil and gas stock market sector prices.

The policy implication, throughout this chapter is that the deregulation of electricity markets is desirable for consumers. In deregulated markets, it is put forward, that there is greater dependence for supply costs on global fossil fuel prices, as reflected in energy market sector prices. It is therefore likely to result in less cost to the consumer due to less interference by government, either directly or indirectly, through private or public monopoly pricing.

Country energy markets (and therefore country electricity markets) were affected to varying degrees by the global financial crisis. A limitation of the study is that structural breaks around the date of the onset of the crisis are not studied in this chapter. A full period is studied from 1999 to 2011 because the use of monthly data (risk ratings are reported monthly) precludes the splitting of the sample, which would produce less robust results due to a loss of degrees of freedom. However, structural breaks around the date of the onset of the global financial crisis are less relevant for Asia. The South East Asian region was less affected by the 2008 global financial crisis than other regions and countries, such as those in the USA and Canada, the European Monetary Union and the United Kingdom.

Asian economies according to the Asian Development Bank (2013) were less impacted by the US led global financial crisis. However, the evaluation department of the Asian Development Bank warns that Asian economies must address the issues of fiscal sustainability (aggressive public sector expenditure management), building robust systems for social protection (focusing on the socially vulnerable) and providing sufficient capital adequacy in their financial systems to fight financial distress connected with global shocks. Fair electricity pricing will contribute to fiscal sustainability and social protection.

Many country electricity markets are fragmented and consist of markets within markets in the various regions within those countries. A strong assumption in this study is that the countries that quote electricity prices have the semblance of a unified electricity market. Often governments directly intervene in the price setting mechanism. This results in expensive electricity whether it is over-or under-priced. Even if electricity is under-priced by government interference, the taxpayer is often subsidising it in some way. Many electricity markets are over-regulated and inefficient with the condoning by governments of private or public monopolies in power generation and distribution. Apart from the impact of these factors on perceived political stability, there are few if any economic or welfare benefits attached to monopoly or cartel pricing.

The concept of electricity liberalisation or deregulation is based on the premise that, historically, electricity supply has been a natural monopoly and, as such, it has required costly regulation to enforce competition. The British model is the standard in OECD countries, which, in turn influence the standards in South East Asian countries. The British model began in the late 1980s with the privatisation and de-integration of the electricity industry where a system of competition was established to auction spare capacity through a central system. Such a system benefits large industrial consumers, but the benefits to domestic consumers are questionable when electricity supply through a public monopoly is compared to that through a regulated private monopoly. Whichever the case, monopoly pricing through market power is expected to inflate electricity prices. This important incontrovertible fact may be the definition of any similarity between Western European type and South East Asian electricity markets.

Another assumption in this study is that economic, financial and political risk ratings for the various countries reflect the degree of economic and financial health and the level of political stability in those countries. Economic and financial risk ratings are based on balance of payments in current account and capital account numbers respectively. Political risk ratings are subjectively quantified by risk ratings experts to reflect political factors (for example, the history of law and order and the levels of corruption) and will therefore reflect to a degree the level of government interference in market pricing mechanisms.

This study takes the position that if a country electricity market is relatively deregulated, electricity prices in that country should reflect a greater degree of global energy supply and demand interaction in the international prices of fossil fuels, as well as the country's relative economic and financial strength. If political instability and other domestic factors dominate, such as, the degree of government pricing interference as reflected in political indicators, then these markets are relatively regulated.

The following examples of electricity markets in South East Asia highlight the economic, financial and political forces at work within the markets. Chinese and Malaysian examples show contrasting levels of market development, deregulation and government interference. In 1996 China's Electric Power Law was implemented in order to develop the electricity industry and protect consumers and investors. It aimed to regulate the generation, distribution and consumption of electricity. In 2002 the State Power Corporations monopoly was dismantled and 11 smaller corporations were established. The State Power Corporation had previously owned 46 % of electricity generation and 90 % of electricity of supply assets.

Ongoing reforms are dealing with the separation of power plants from power supply networks, privatisation of a significant amount of stated owned property, the encouragement of competition and the revamping of pricing mechanisms. In relation to energy supply, 78 % of power is generated from coal fired plants and around 15 % is hydropower (China Electricity 2013). China is a very large electricity market and economy. In light of the reliance on fossil fuels for energy supply and the favourable competitive environment in the electricity industry it is expected that the relationship between electricity and energy sector prices will be stronger than that with many other countries. The evidence should support, at least in the long-term, a greater degree of deregulation.

The Hong Kong economy and electricity market still operates under the basic law applying prior to the British handover to mainland China in 1997 and therefore with relative autonomy from mainland China. The Hong Kong electricity market is dominated by a non-state-owned enterprise in the Hong Kong Electricity Company which is the main operating company of Power Assets Holdings founded in 1889. It is responsible for the generation, transmission and distribution of electricity to Hong Kong and Lamma Island. The main electricity generation plant is on Lamma Island where it also has invested significantly in wind and solar generation capacity. It is a modern globalised company with the global earnings of Power Assets Holdings outstripping domestic earnings in recent years (Hong Kong Electricity 2013). However, domestic share market forces are expected to dominate electricity market pricing in the long-term.

Due to a strong surge in demand for electricity, the Malaysian government divested Tenaga Nasional (the owner of the national grid) in 1992 and awarded independent power producers (IPPs) licences to build plant and sell electricity to Tenaga for transmission and distribution. The licences were awarded without tender and questions have been asked as to whether the licences were awarded to friends of the government and whether large profits were made at Tenaga's expense (Malaysian Electricity 2013). Malaysia's electricity market is also small compared to that in China. Whilst fossil fuels dominate renewables, such as hydropower in energy supply, the relationship between electricity prices and the energy market sector prices is expected to be lower due to the probability government indirect interference in electricity pricing.

Thailand's electricity market is a state owned monopoly. The Electricity Generating Authority owns and manages most of Thailand's electricity generating capacity as well as the nation's transmission networks. It sells electricity to the Metropolitan Electricity Authority for Bangkok and to the Provincial Electricity Authority for the rest of Thailand. It is therefore quite possible that monopolistic pricing reduces the impact of international factors. However, in recent debates about a regional Asian electricity hub the Thailand Minister for Energy in March 2013 has committed to a degree of regional integration saying Thailand had a competitive advantage over China as Thailand has electricity connections with Myanmar, Laos, Cambodia and Vietnam (Thailand Electricity 2013).

The electricity market in the Philippines is dominated by the Philippines Electricity Market Corporation, which was created by the Department of Electricity in 2001. It states that its principal purpose is to establish, maintain, operate and govern an efficient and transparent and reliable market for the wholesale purchase of electricity and ancillary services. To this extent the Philippines electricity market is quite unique in the region. Whilst a public corporation governs the market the prices of electricity are set by the interaction of supply and demand forces in the Wholesale Electricity Spot Market, which treats electricity as a commodity and the market reflects the actual cost of electricity with further cost savings by efficient production (Philippines Electricity Markets 2013). It is likely that global fossil fuel prices are the major supply costs and that the Philippines market is therefore more globally integrated than other Asian markets.

Returning to the research issues in this chapter, the following questions are asked in respect to the South East Asian countries selected for the study: How are electricity prices in the countries determined? Are these prices truly endogenous in models where their prices, energy stock market sector prices (as proxies for global fossil fuel prices) and country risk ratings (as proxies for economic and financial strength and political stability) interact? Are global forces largely at work or do the forces largely relate to domestic government price interference? Of course it could be that, in reality, electricity prices and energy stock market sectors are the leading indicators and economic health, financial strength and political stability are the lagging indicators. If this is the case, electricity markets and/or energy markets may be the partial drivers of a country's economic and financial strength or weakness as well as its perceived political stability or instability. It is also possible that energy stock market sectors are the drivers of electricity markets.

Thus the specific issues to be tested are as follows:

1. Are there long-term cointegrating relationships within South East Asian country electricity markets, the country energy stock markets and the various components of country risk ratings for each country studied? If there is evidence of cointegration, rational expectations and market efficiency in electricity markets is implied. This is also an indicator of a less regulated market in terms of government interference. This first issue is about evidence of cointegration and long-term relationships.
2. In terms of short-term dynamics, are South East Asian country electricity prices truly endogenous for each country studied? This too will provide evidence in relation to relative deregulation (for example, if economic, financial factors or political factors dominate as leading indicators). This second issue is about endogeneity when all specified variables interact in the short-term and will indicate any short-term electricity policy differences within the various countries.

Various studies have shown significant contemporaneous as well as lagged relationships between electricity markets and fossil fuel prices (for example, Bosco et al. 2006; Asche et al. 2006; Mjelde and Bessler 2009; Mohammadi 2009; He et al. 2010; Mautinho et al. 2011; Ferkingstad et al. 2011; Furio and Chulia 2012). Recent studies (for example, Simpson et al. 2012; Simpson and Mon Abraham 2012) have examined relationships between energy stock market sectors and electricity prices in various countries finding mixed evidence of cointegrating relationships and electricity sector endogeneity and thereby identifying countries where there appears a greater or less degree of electricity market liberalisation. There are extensive studies that have examined the relationships between stock market prices and sovereign risk ratings, including pre and post-crisis periods in their studies (for example, Erb et al. 1996; Diamonte et al. 1996; Hill 1998; Radelet and Sachs 1998; Ferri et al. 1999; Reisen and von Maltzan 1999). The evidence connecting energy stock market prices to country risk economic, financial and political components, rather than sovereign risk ratings is lacking. The literature review reveals no similar approaches in studying the dynamic interaction of country electricity prices, energy stock market prices (reflecting global fossil fuel prices) and indicators of economic and financial strength and political stability in economic risk, financial risk and political risk ratings.

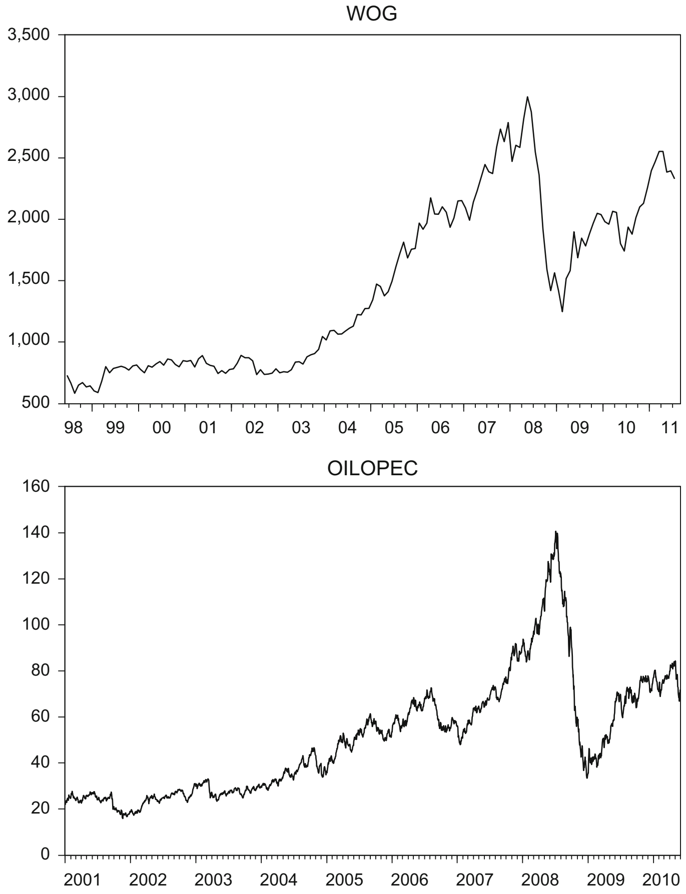

Fig. 6.1 The relationship between the global stock market energy sector and global oil prices (Note: WOG is the world stock market energy sector price index. OILOPEC is the OPEC oil price. Data sourced from DataStream)

In this chapter, Sect. 6.2 deals with the data, methodology and the model, followed by Sect. 6.3, which covers the findings. Section 6.4 provides a discussion of the findings and the conclusion is provided in Sect. 6.5.

6.2 The Data, Methodology and Model

The study specifies a Vector Error Correction Model (VECM) of country electricity markets against country energy stock market sectors and proxies for a country's relative economic and financial strength and political stability. All data are extracted as at the end of each month. Prior to an explanation regarding the data it is important to investigate the relationships between the global stock market energy sector and global oil prices. This is because the study asserts that energy stock market sector prices in various countries largely reflect global fossil fuel prices.

Figure 6.1 shows the strong global relationship between energy stock market sectors and oil prices. The assumption therefore is that country energy or oil and gas stock market sectors are strongly related to the global prices of fossil fuels. A key variable in the model to be presented and tested is the country energy stock market sector as an indicator of global fossil fuel prices.

6.2.1 The Data

End of month data for electricity prices are extracted from Bloomberg's and that for energy stock market sectors from DataStream for the period December 1999 to December 2011. Electricity prices in each country reflect the prices paid by domestic users. Energy sector indices represent listed companies in each country in the businesses of production and distribution of energy in the predominant forms of oil, gas and coal. The global prices of fossil fuels drive energy stock market sectors (See Fig. 6.1).

To partially control for differences between measurements of prices in different countries, the electricity and energy price data are converted to logarithms. The full period is studied without any loss of degrees of freedom and it thus includes the rapid fall in energy prices during the global financial crisis from 2008, but as previously stated the effects of the global financial crisis on stock markets were not as great in South East Asian markets compared to Western type markets. In view of this fact and also due to the fact that there would be a significant loss in degrees of freedom if two sample periods were to be studied on the same data set, the full period only is selected as the sample for the study.

The components of country risk data are taken from the International Country Risk Guide (2012). These are end of month data and include economic and financial risk (as a basic indicator of a country's ability to perform its external obligations and thus an indicator of relative economic and financial strength) and political risk (as a basic indicator of a country's willingness to perform its external obligations and thus an indicator of a country's relative political stability and political will). Economic and financial risk ratings are objectively measured based on balance of payments current account and capital account data respectively. Political risk ratings are subjectively quantified based on the surveyed opinions of risk experts. The higher the ratings in each case the lower the risk. In other words the higher the ratings, the stronger the requisite implementation of macro and micro-economic and political reforms necessary for an efficient deregulated market.

6.2.2 The Model

The model to be tested is as follows:

$$EL_{i_t} = \alpha_{i_t} + \beta_1(EL_{i_{t-n}}) + \beta_2(EM)_{i_t} + \beta_3(EM_{i_{t-n}}) + \beta_4(CR_{i_t}) + \beta_5(CR_{i_{t-n}}) + e_{i_t} \tag{6.1}$$

Where:

EL_{i_t} is the electricity price in country i at time t.

EM_{i_t} is the energy sector stock market index in country i at time t. This variable represents global economic factors, such as global fossil fuel prices impacting country energy market prices.

α_{i_t} is the regression intercept reflecting current commencement prices or base electricity market prices and electricity market conditions for country i at time t.

CR_{i_t} and $CR_{i_{t-n}}$ are vectors of country risk ratings in country i at times t and $t - n$, representing separate components of country risk in economic risk, financial risk and political risk.

e_{i_t} is the residual of the regression for country i at time t representing the contribution to the variance of country electricity prices from factors other than risk factors and energy sector prices in country i.

n denotes the optimal lag determined by lag exclusion tests and information criteria.

6.3 Findings

Phillips-Perron (PP) unit root tests (Phillips and Perron 1988) are applied to the data. The unit root test results are shown in Table 6.1.

The results of the unit root tests are confirmed by VAR based stability condition tests, which are reported in Column (2) of Table 6.2. The Philippines, according to unit root tests have first difference stationary variables, but the VAR is unstable according to the VAR stability condition tests. The findings overall indicate that all variables in the specified model and the errors of the relationships between those variables in the cases of all country electricity markets are integrated non-stationary processes. This is because all first difference test statistics are significant at the 1 % level. All but the level series errors for the Philippines are significant at the 1 % level. Level series test statistics have a mixture of statistical significance, but still indicate that the level series are non-stationary and this is confirmed in VAR stability condition tests as mentioned.

6.3.1 Cointegration and Endogeneity

The VAR models in level series are specified and VAR based tests for optimal lags and cointegration are undertaken. If the VAR is stable, and if the optimal lag is

Table 6.1 PP unit root tests for variables in the electricity sector regression

Country	Level series Electricity prices/energy prices/ economic risk/financial risk/ political risk ratings	First differences Electricity prices/energy prices/ economic risk/financial risk/ political risk ratings	Level series errors/first difference errors
(1)	(2)	(3)	(4)
Malaysia	−3.5343*/−1.8177/−3.4691**/ 2.5936***/−2.1180	−12.4423*/−12.1194*/ −11.9546*/−11.8336*/ −9.9805*	−3.6176*/ −12.8633*
Thailand	−2.2981/−2.3244/−2.8728***/ −1.6051/−1.0018	−11.5357*/−11.1031*/ −13.5672*/−15.0264*/ −12.1274*	−4.1480*/ −16.6929*
Hong Kong	−2.0088/−1.4155/−2.7470***/ −0.9575/−2.4881	−12.7367*/−14.4561*/ −11.9077*/−11.9489*/ −10.8198*	−4.7513*/ −23.8708*
China	−1.2102/−0.2559/−2.4200***/ −1.6719/−1.3619	−11.9721*/−11.8605*/ −13.6928*/−12.0401*/ −13.1094*	−4.0236*/ −14.8411*
The Philippines	−1.4489/−0.4620/−3.2906**/ −0.9482/−2.4339	−11.2770*/−12.1369*/ −13.2597*/−12.3693*/ −11.3951*	−1.7499/ −11.4507*

Note: The numbers in this table in columns 2, 3, and 4 are the PP test statistics for electricity prices, energy sector prices, economic risk, financial risk and political risk respectively
*Significance levels are at 1 %; **Significance levels are at 5 %; ***Significance levels are at 10 %. Critical values for PP tests are at 1 %, −3.4768; at 5 %, −2.8818; at 10 %, −2.5777

determined and cointegration (Johansen 1988) is proven, the VAR is re-specified into a VECM (that is, using the optimal lag as determined from the VAR information criteria). The VECM is re-tested for cointegration and the variables tested for exogeneity. Granger block exogeneity (causality) tests (Granger 1988) are deemed inappropriate with monthly data, where it is felt that the optimal lag in daily data may only be 1 or 2 days. Daily data is not available for risk ratings so the study becomes one in monthly data for all variables. For evidence of exogeneity the study reverts to the error correction terms (ECTs) of the VECM. The VECM ECTs are examined to assess the speed of each model towards equilibrium and thus the true endogenous variable. The magnitude of the adjusted R square values in the VECM, to the extent that their rankings coincide with the rankings of the magnitude of the significant t statistics for the endogenously treated variables, also confirms endogeneity.

The results for cointegration and exogeneity testing are displayed in Table 6.2. Column (4) deals with long-term equilibrium relationships (this is after the Johansen cointegration tests are performed on the specified VECM). Column (1) refers to the country. Column (2) shows the results of the VAR stability condition tests for unit roots. Column (3) shows the VAR optimal lag based on the Likelihood Ratio (LR), Final Prediction Error (FPE), Akaike (AC), Schwartz (SC) and Hannan-Quinn (HQ) information criteria. Column (4) shows the results of the VECM based cointegration tests and the number of cointegrating equations,

Table 6.2 Results for models of country electricity pricing

(1) Long-term equilibrium	(2)	(3)	(4)	Short-term dynamics	(5)	(6)
Country	VAR stability condition check	Optimal lag in months from VAR criteria (information criteria used)	Cointegrating equations from VECM tests (tests used/assumptions)	Summary of electricity pricing links with economic, financial, political and energy market factors	Unlagged endogenous variable (t statistic/ adjusted R square value)	Lagged exogenous variables (t statistic)
China	Stable	1 (according to FPE, AC, SC and HQ)	1 (according to Trace and Maximum eigenvalue statistics/assumptions of no trend and no intercept)	**Non-political factors dominate**	Economic risk (−3.6730**/ 0.0648*)	Electricity market (+1.8528**) and the energy market (−1.3799***)
Malaysia	Stable	1 (according to FPE, AC, SC, and HQ)	NONE (according to Trace and Maximum Eigenvalue statistics)	**Non-political factors dominate**	Financial risk (+3.6896**/ 0.0955*)	Electricity market (+1.5532***) A –ve link with energy prices
The Philippines	Unstable	1 (according to FPE, AC, SC and HQ)	1 (according to Trace and Maximum Eigenvalue statistics/Assumptions are that relationship is linear with a trend and an intercept)	**Political factors dominate**	Finance risk (−3.5959**/ 0.0839*)	Political risk (+1.6120***) electricity market energy markets show –ve link
Thailand	Stable	1 (according to LR, FPE, AC, SC and HQ)	1 (according to Trace and Maximum Eigenvalue statistic/quadratic assumption with intercept and trend)	**No significant domination**	Political risk (−3.3450**/ 0.0520*)	All other variables not statistically significant at the 10 % level. A +ve link with electricity market and a –ve link with energy sector
Hong Kong	Stable	1 (according to SC and HQ). 2 (according to LR, FPE and AC)	NONE (according to Trace and Maximum Eigenvalue statistics)	**Non-political factors dominate**	Electricity market (−5.0081*/ 0.1369*)	Lagged electricity market (+2.0324**) energy market (−1.4581***)

Note: *Significance levels are at 1 %, **at 5 % and ***at 10 %

according to Trace and Maximum Eigenvalue test statistics and reports the assumptions of the model for the electricity prices models (e.g. linear trend with no intercept). Thus Columns (5) and (6) of Table 6.2 deal with short-term dynamics and endogeneity after examination and analysis of the VECM error correction terms, which show the speed of the models towards equilibrium when each variable in the model is treated endogenously. Column (5) shows the true endogenous variable in a model where all specified variables interact on the optimal lag of 1 month, as determined by the magnitude of the model's ECT which is reported if the relative t statistic is significant up to the 10 % level. Column (5) also shows the value of the t statistic and the adjusted R square value. The ECT shows the speed of the model towards equilibrium and it assumed that the model with a significant ECT of greatest magnitude indicates the model with the best fit. Column (6) of Table 6.2 therefore confirms true exogeneity of the remaining variables in the model and provides the significant t statistic in order of magnitude. The t statistics of other exogenous variables are not shown if they are not significant up to the 10 % level.

6.4 Discussion

The results suggest that in all countries (with the exception of the Philippines), the specified VAR is stable with integrated non-stationary processes. In all cases an optimal lag of 1 month is decided based on the majority of the information criteria. That is, after 1 month in each case the models commence their path towards equilibrium. In all cases except Malaysia and Hong Kong, there is at least one cointegrating equation according to Trace and/or Maximum Eigenvalue test statistics. This indicates that, in the specified country models where cointegration is evident, the specified variables together achieve stability in the long-term. In the cases of China, the Philippines and Thailand there is significant evidence of long-term equilibrium relationships between electricity and energy markets and economic, financial strength and political stability. It may be that domestic factors, such as government pricing interference and the condoning of private or public monopolies have less importance over the long-term than in Malaysia and Hong Kong. However, even in the cointegrated markets, it must be also noted that, with low explanatory power in each case, the best that can be said is that the models may be useful as partial forecasting mechanisms.

The question of true endogeneity is better answered by the analysis of the error correction terms (ECTs) from the respective country VECMs (that is, compared to Granger block exogeneity Wald tests, which might be deemed more reliable if daily data were available). The true endogenous variable is indicated by the greatest significant magnitude of the ECT for that model (that is, with significance levels up to 10 %). This is because the ECT magnitude shows the speed of the model towards equilibrium (that is, the greater the magnitude, the greater the speed). If the sign of that term is negative, mean reversion (that is, equilibrium) is achieved from above the mean and if positive it is achieved from below the mean. The largest significant ECT coincides in each case with the largest adjusted R square value, which confirms the true model specification. The results from an examination of the magnitude of significant ECTs and adjusted R square values from the VECMs for each country show that the economic risk rating is the true endogenous variables in the case of China. In the cases of Malaysia and the Philippines financial risk is endogenous. In Thailand, political risk is endogenous. It is only in Hong Kong that the electricity market is endogenous as originally specified. In each model, exogeneity differs according to strength and significance. In this discussion it is important to bear in mind that the higher a risk rating or risk score (for economic, financial and political risk), the lower the risk (or the greater the economic and financial strength and the greater the perceived political stability respectively).

Asian developing economies of China, Malaysia, the Philippines, Thailand and Hong Kong show mixed results. In China, economic strength is endogenous and driven significantly by the electricity market and the energy market. Economic, financial and energy market forces rather than political factors appear at work in China. In Malaysia and the Philippines, financial strength is endogenous, driven in the case of Malaysia mainly by the electricity market and in the case of the Philippines mainly by political factors. This is despite the fact that in the Philippines, there is a wholesale domestic electricity spot market, which is in turn driven by the interaction of supply and demand. The domestic electricity supply costs in the Philippines are more likely to fully reflect global prices of fossil fuels. In Thailand, political stability is endogenous, driven mainly by a collective exogeneity of all other specified variables with none by itself a significant exogenous force. In Hong Kong, the electricity market is endogenous, driven significantly by that market's lagged prices and the energy market. Hong Kong's market is dominated by a private sector company where prices are likely to reflect domestic share market conditions.

Conclusion

Support is provided in this South East Asian study for past evidence of significant relationships between energy markets and electricity markets and between stock markets, stock market sectors and risk ratings. Except in the cases of Malaysia and Hong Kong there is evidence of cointegration. That is, long-term equilibrium relationships exist in China, Thailand and the Philippines and therefore evidence of greater relative progress in electricity market deregulation over the long-term in those markets is provided. The cointegrated markets demonstrate a degree of long-run market efficiency and rational expectations even though state owned enterprises monopolise electricity generation and transmission in those countries. In the Philippines the government oversees a unique wholesale electricity spot market, which has developed with market prices of electricity expected to be largely driven by global fossil fuel prices.

In the short-term it is evident that the models in each country studied show varying leading and lagging influences of electricity markets, economic health, financial strength, energy stock market sectors and political factors. In terms of short-term dynamics, the interaction of economic, financial factors, energy markets and electricity markets when political risk is not significant, suggests less short-run government interference in electricity pricing in China, Malaysia and Hong Kong, even though in the long-term for Malaysia and Hong Kong there is no evidence of cointegration. The apparent conflicting evidence between long- and short-run relationships may be explained by differences in each country in short-run electricity policy effects. However, the results are sufficiently encouraging to suggest that in future research utilising a similar methodology may be applied to a greater number of countries to provide further insights into electricity market deregulation.

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Geopolitical Market Concentration (GMC) Risk of Turkish Crude Oil and Natural Gas Imports

7

Özgür Arslan-Ayaydin and Inna Khagleeva

Abstract

This chapter explores the geopolitical risk of Turkey's crude oil and natural gas diversification portfolios. We use the methodology of Chaterjee (Strateg Anal 36(1):145–165, 2012) to forecast the Geopolitical Market Concentration (GMC) risk of Turkey's diversification portfolios under worst and best case scenarios. Our analysis is based on the market shares and the political stability of countries supplying crude oil and natural gas to Turkey. The results are robust to the choice of parameters in the double exponential smoothing method, which we use for forecasting.

7.1 Introduction

Energy is a key input into all economic processes. That makes energy security – the uninterrupted physical availability of energy at an affordable price – a fundamental necessity for any economy. Factors that instigate energy insecurity reside mostly in countries exporting energy. These factors include political instability, geopolitical rivalries, regional supply shortfalls, higher energy prices, imminent depletion of reserves and bottlenecks in the supply chain. However, in the long-run, fiercer competition for oil and natural gas among energy-importing nations is likely to contribute to energy insecurity (Isenberg et al. 2002).

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Ideally, to ensure access to crude oil and natural gas, importing countries must assure the continuity, consistency and adequacy of supply at a reasonable cost in not only short but also long run. In the long run, energy security entails access to affordable sources of energy with protections against price and volume risks. Less dependence on imports, lower degree of import concentration, higher ratio of domestic inventories to imports and greater diversity of exports are essential for energy security in the long term.

The short term, on the other hand, is a period of time during which no radical change occurs in the quality of the factors deployed. Therefore, short term energy security involves the ability to react promptly to sudden changes in energy supply and demand, such as disruptions in energy supply resulting from geopolitical, military or civil developments.

The surge in oil prices in 2007–2008 emphasized that long-term energy security calls for sound policy actions by importing nations. From a long term perspective, we can classify risks confronting energy importing nations as systematic risks and unique risks. Systematic risks concern common risks related to international crude oil and natural gas markets, whereas unique risks are associated with dependence on specific regions supplying them. Diversification of crude oil and natural gas supply does not provide energy security by eliminating systematic risks, but by reducing unique risks by diversifying among sources that supply energy. Therefore, diversification provides energy security for importing countries by decreasing their exposure to country-specific risks of energy supplying countries. By diversifying among suppliers of energy, an energy importing country aims to secure a stable supply of oil and natural gas that might otherwise be endangered by over-dependence on a single import source (Koyama 2004).

However, there are limits to diversification. These limits include the following (Vivoda 2009):

– Availability of transportation infrastructure and capacity to transport oil and natural gas from alternative exporters;
– Geographic conditions, such as freight costs, relative distance from major exporting regions and security of transport routes;
– Economic and political ability to meet the costs to secure access to alternative oil supplies; and
– Political relations with energy-exporting countries.[1]

Energy security is a continuing concern for Turkey, which is heavily reliant on energy imports. Specifically, Turkey depends on imports for 92 % of its crude oil needs, while its natural gas dependency rate is 98 %. Further, Turkey's demand for energy has been increasing in direct proportion to the increase in its GDP at an

[1] For example, in October 2006, due to diplomatic pressure by the US, IMPEX, which is a Japanese oil company, had to pull out its majority stake in the Azedegan oil field in Iran (Dorraj and Currier 2008).

average of 6 % per year and is expected to reach 130 billion MW by 2023 (Dereli 2013). Rising demand for imported natural gas and crude oil contributes to the wide current-account deficit in Turkey, which totals to around 6 % of the country's GDP. The deficit has been financed mainly with flows from foreign funds, which has left the economy vulnerable to the whims of international investors (Wall Street Journal 2013). We should also note that a $10 per barrel drop in the oil price cuts as much as $4 billion off Turkey's annual current account deficit, which is around $65 billion (Financial Times 2012). Cohen, Joutz and Loungani (2011) calculate a country-specific index (CSI) for the concentration in crude oil suppliers. Smaller values of the CSI indicates more diversification and hence lower risk – in the case of only one supplier, the CSI takes on its maximum value of 100 and if CSI is above 10, then the country is classified as being highly vulnerable to disruptions in energy supplies. Their results show that the CSI for Turkey has risen from 13.52 in 1990 to 21.59 in 2008.

This chapter aims to find out the geopolitical market concentration (GMC) risk of Turkey's crude oil and natural gas diversification portfolio and to assess whether its portfolio is concentrated to several countries or dispersed. To do this, we follow the methodology of Chatterjee (2012). We evaluate the GMC risk of Turkey's current (2010–2011) and future (2012–2016) diversification portfolios. We use the exponential smoothing method of trend fitting and forecasting with time series data to estimate the concentration of suppliers. For the political risk parameters, in our analysis we use the Blyth and Lefèvre (2004) model. We also analyze and compare the GMC risk of the Middle East, which holds 59.9 % of the world's crude oil and 36 % of the world's natural gas reserves, and other regional suppliers in the diversification portfolio of Turkey over past, present and future time periods. We show that our results are robust to the choice of parameters in the double exponential smoothing model that we use for forecasting.

Our chapter is structured as follows: Sect. 7.2 describes the data and explains our methodology and the model for the GMC risk. In Sect. 7.3 we provide our results and discussions on Turkey's oil and natural gas imports. Section 7.4 presents the robustness checks. Finally, the last section concludes.

7.2 Data and Methodology

We obtained the data for our study from the Energy Market Regulatory Authority's (EPDK) official website.[2] In our forecast, we use longitudinal data from 2005 to 2011.

[2] www.epdk.gov.tr

7.2.1 Forecast

We use the double exponential smoothing technique, which provides a good fit when data shows a trend, to forecast Turkey's future imports and production. This method involves updating two parameters, level E_t and trend T_t, at each time period. The level is a smoothed estimate of the value of the data at the end of each period t. The trend is a smoothed estimate of the average growth at the end of each period. The following is the formula for double exponential smoothing:

$$E_t = U(E_{t-1} + T_{t-1}) + (1 - U)X_t \tag{7.1}$$

$$T_t = VT_{t-1} + (1 - V)(E_t - E_{t-1}) \tag{7.2}$$

where, U and V are arbitrarily chosen smoothing constants ranging from 0 to 1. We present all sets of results for $U = V = 0.4$ and discuss other choices. X_t is the observed value of time series at time t. There are several ways to choose the initial values for the trend and the level. We choose $E_{t_0} = X_{t_0}$ and $T_{t_0} = 0$, where subscript t_0 refers to the first year of the time series. An h-step forecast combines estimates of the level and trend at the last available data point:

$$\hat{X}_{t+h} = E_t + hT_t \tag{7.3}$$

Thus in year 2011, to forecast Turkey's oil import in 2016, we first estimate level E_t, and trend T_t for $t = 2011$ recursively starting from the origin of the time series and then compute the future value for import as $\hat{I}_{2011+5} = E_{2011} + 5T_{2011}$.

7.2.2 Model for Geopolitical Market Concentration Risk (GMC)

We evaluate the geopolitical market concentration risk (GMC) using the model of Blyth and Lefèvre (2004), which is based on Hirschman (1945) and Herfindahl (1950). This model has been applied by Chatterjee (2012) to forecast the GMC of the crude oil diversification portfolio of India. The inputs for this model are market shares of oil supplying countries and a proxy for the country risk:

$$GMC_t = \sum_i r_{ti} S_{ti}^2, \tag{7.4}$$

where $S_{ti} = I_{ti}/(I_t + P_t)$ is the market share of the i-th crude oil supplier in year t. I_{ti} is the import from the i-th supplier in year t. P_t is the total oil production of Turkey in year t. Further, $I_t = \sum_i I_{ti}$ is the total import and $r_{ti} = \frac{100}{R_{ti}}$ is a modified risk of the i-th supplier.

The squaring of market shares S_{ti} results in assigning higher risk to countries with larger shares in the total oil portfolio. For example, the more suppliers the importing country has and the higher the equality of shares, the less risky is the oil

Table 7.1 ICRG risk rating of suppliers of crude oil and natural gas to Turkey (present and forecast)

			2012 (Forecast)		2016 (Forecast)	
Country	2010	2011	WC	BC	WC	BC
Algeria	70.8	71.3	62.5	76.0	55.3	80.8
Azerbaijan	76.8	74.0	68.3	76.8	57.3	79.0
Iran	63.5	68.3	61.8	73.0	55.0	76.8
Iraq	59.3	58.5	52.3	62.3	45.3	68.0
Italy	74.5	74.5	69.5	76.3	67.8	80.5
Kazakhstan	70.8	72.0	66.0	75.0	58.5	78.0
Libya	76.0	80.5	72.3	81.5	62.3	83.8
Nigeria	61.3	65.8	58.3	69.0	51.8	74.3
Russia	72.3	72.8	65.8	75.8	59.0	79.0
Saudi Arabia	73.0	80.3	71.5	82.5	64.3	84.5
Syria	65.8	67.0	63.0	70.8	57.5	75.5
United Kingdom	73.8	77.3	72.0	80.8	70.5	85.3

Notes: Reproduced from International Country Risk Guide, 2012, Current Risk Ratings and Composite Risk Forecasts. © The PRS Group, Inc. http://www.prsgroup.com/ICRG_Variables.aspx. *WC* corresponds to the worst-case scenario, while *BC* relates to the best-case scenario

import portfolio. However, if the share of a supplier doubles, the risk of this supplier's contribution quadruples.

The International Country Risk Guide (ICRG) composite rating R_i has been estimated by the PRS group and is shown in Table 7.1. Countries are rated on a scale of 1–100 by the ICRG – the higher the rating, the safer the country and thus the lower the risk. This rating is based on an assessment of 22 variables for three types of risk: political, financial and economic (The PRS Group, Inc. 2012). The total score ranges from 0 to 100. Accordingly, countries with scores from 80 to 100 are put into the Low Risk group. Scores from 0 to 49.9 correspond to the 'very high risk' group. Noteworthy, Eq. 7.4 uses the reciprocal of R_i multiplied by 100. Thus, in this paper, higher levels of the GMC correspond to higher risk.

Based on the ICRG rating we can assess the individual risk of countries supplying oil to Turkey. None of the suppliers belongs to the 'very high risk' group. The 'safest' oil supplier is Saudi Arabia, which belongs to the Low Risk group. However, the import share of this country is gradually decreasing (see Sect. 7.3.1). In contrast, Iraq has the highest risk score, but the import share of Iraq is increasing.

7.3 Results and Discussion

7.3.1 Forecast of Turkey Oil Import

Table 7.2 shows the total oil import and production of Turkey in metric tons, through the years 2002–2011. It can be seen from the table that, through the years, although the domestic production of crude oil is stable, there is a steady decline in imports, namely around 24 % from year 2002 to 2011.

Table 7.2 Total crude oil import and production of Turkey

Years	Import	Production
2002	23,707,589	2,397,812
2003	24,028,667	2,366,912
2004	23,917,019	2,281,005
2005	23,389,647	2,275,143
2006	23,786,875	2,182,654
2007	23,445,764	2,097,065
2008	21,833,471	2,217,225
2009	14,219,427	2,237,211
2010	16,873,392	2,538,317
2011	18,092,206	2,433,408

Source: Republic of Turkey, Energy Market Regulatory Authority (EPDK). www.epdk.gov.tr (The numbers are indicated in metric tons)

Table 7.3 Crude oil import portfolio of Turkey, historical data and forecast, (thousands of metric tons)

Countries	2006	2007	2008	2009	2010	2011	2012[a]	2016[a]
Iran	9,121	8,356	7,800	3,228	7,261	9,287	8,640	12,841
Iraq	552	865	1,874	1,733	2,001	3,071	3,369	5,613
Saudi Arabia	3,354	3,556	3,073	2,096	1,953	1,965	1,431	81
Syria	–	244	515	160	406	255	282	199
Total Middle East	**13,027**	**13,021**	**13,262**	**7,217**	**11,621**	**14,578**	**13,722**	**18,733**
Import dependence on Middle East	***0.54***	***0.56***	***0.61***	***0.51***	***0.69***	***0.81***	***0.86***	***0.88***
Azerbaijan	–	–	–	77	–	81	50	51
Georgia	–	–	–	36	–	–	–	–
Italy	–	447	447	249	110	116	–	–
Kazakhstan	–	–	636	522	1,786	1,186	1,619	2,536
Libya	4,165	612	77	139	–	–	–	–
Nigeria	–	–	–	190	–	–	–	–
Russia	6,871	9,365	7,137	5,762	3,320	2,131	476	0
UK	–	–	184	–	–	–	–	–
Others total	**11,036**	**10,424**	**8,481**	**6,975**	**5,216**	**3,514**	**2,145**	**2,587**
Import dependence on other countries	***0.46***	***0.44***	***0.39***	***0.49***	***0.31***	***0.19***	***0.14***	***0.12***
Total	**24,063**	**23,445**	**21,743**	**14,192**	**16,837**	**18,092**	**15,867**	**21,320**

Notes: [a]Indicates the forecasted values based on the model in Sect. 7.2.1

From the data provided in Tables 7.2 and 7.3, Fig. 7.1 shows that the composition of crude oil imports of Turkey has changed dramatically towards more dependence on the Middle East. In 2006, the total share of Middle Eastern countries was 0.54, while in 2011 this share rose to 0.81. The forecasts for 2012 and 2016 are 0.86 and 0.88. In addition, diversification also suffers from the

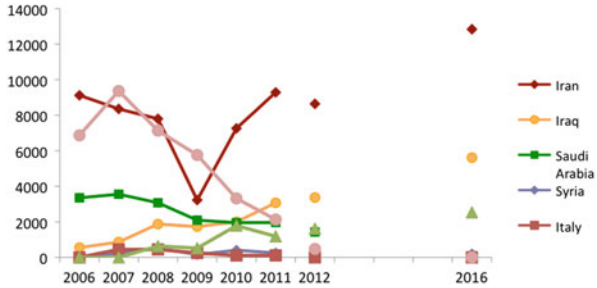


Fig. 7.1 Crude oil import portfolio of Turkey, historical data and forecast (*Notes:* In the figure, the *vertical* axis shows imports in thousands of metric tons, whereas the *horizontal* axis shows the years. Forecasted values are displayed as *dots*)

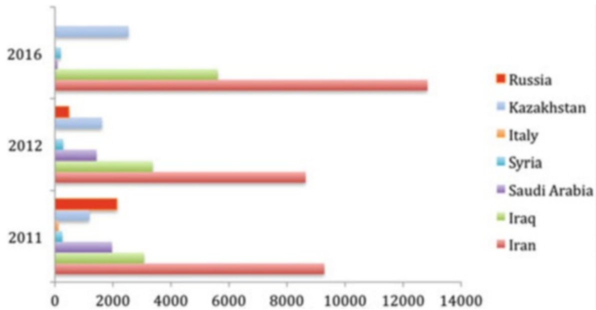


Fig. 7.2 Bar chart of oil import portfolio of Turkey (*Notes:* The *vertical* and the *horizontal* axes of the graph relate the years and imports in thousands of metric tons respectively. Plots for years 2012 and 2016 represent our forecast)

negative trend in the number of oil suppliers. Although Turkey seems to increase number of oil suppliers at the beginning (from 5 in 2006 to 11 in 2009), by 2011 Turkey's supply of crude oil is dominated by only eight countries in 2011. Based on our forecast, the number of suppliers falls to seven in 2016. Moreover, the shares of Iran and Iraq are gradually increasing, while the contribution of Saudi Arabia is significantly diminishing. Figure 7.2 shows the detrimental trend in the diversification of oil suppliers in the long run. As we show later, all of these tendencies lead to an increase in GMC risk.

7.3.2 Geopolitical Market Concentration Risk of Turkey's Crude Oil Import Portfolio

This section is based on the model for evaluating geopolitical market concentration risk that is described in Sect. 7.2.2. Table 7.4 presents the current and the forecasted crude oil market concentration, which is based on predicted imports shown in Table 7.3. These values are used as inputs in Eq. 7.4.

Results in Table 7.5 show that the geopolitical market concentration risk of Turkey is increasing in both scenarios. For example, the total Middle East risk is about 0.3496 in 2011, and by 2016 it rises to 0.4426 in the best-case scenario and 0.6263 in the worst-case scenario. Importantly, Iran accounts for 81 % of the total geopolitical market concentration risk of the oil import portfolio of Turkey in 2011.

Table 7.4 Current and forecasted oil market concentration, S_{ti}^2

	2010	2011	2012[a]	2016[a]
Iran	0.0995	0.1824	0.2194	0.2796
Iraq	0.0135	0.022	0.0334	0.0534
Saudi Arabia	0.0112	0.0086	0.0060	0.0000
Syria	0.0004	0.0002	0.0002	0.0001
Total Middle East	***0.1246***	***0.2132***	***0.2591***	***0.3330***
Azerbaijan	0.0000	0.0000	0.0000	0.0000
Georgia	0.0000	0.0000	0.0000	0.0000
Italy	0.0001	0.0000	0.0000	0.0000
Kazakhstan	0.0061	0.0055	0.0077	0.0109
Libya	0.0000	0.0000	0.0000	0.0000
Nigeria	0.0000	0.0000	0.0000	0.0000
Russia	0.0476	0.0113	0.0007	0.0000
UK	0.0000	0.0000	0.0000	0.0000
Others total	***0.0538***	***0.0168***	***0.0084***	***0.0109***

Notes: [a]Forecast based on predicted imports in Table 7.3. These values are used as inputs in Eq. 7.4. Market concentration, S_{ti}^2, is computed as the square of the market share of country *i* in year *t*. For details see Sect. 7.2.2

Table 7.5 The geopolitical market concentration risk (GMC) of oil suppliers of Turkey

Country	2010	2011	2012(WC)*	2012(BC)*	2016(WC)*	2016(BC)*
Iran	0.2212	0.2997	0.3551	0.3006	0.5083	0.3640
Iraq	0.018	0.0383	0.0638	0.0535	0.1179	0.0785
Saudi Arabia	0.0139	0.0114	0.0084	0.0073	0.0000	0.0000
Syria	0.0007	0.0002	0.0004	0.0003	0.0001	0.0001
Total Middle East	***0.2538***	***0.3496***	***0.4277***	***0.3618***	***0.6263***	***0.4426***
Kazakhstan	0.012	0.0046	0.0117	0.0103	0.0186	0.0140
Russia	0.0406	0.0148	0.0010	0.0009	0	0
Others total	**0.0526**	**0.0194**	**0.0127**	**0.0111**	**0.0186**	**0.0140**

Notes: For years 2012 and 2016, as indicated by *, we show the forecasted values. *WC* corresponds to the worst-case scenario, while *BC* relates to the best-case scenario. Countries scoring less than 0.0001 are not included in this table. The GMC is computed by using the Eq. 7.4

7.3.3 Forecast of Turkey's Natural Gas Imports

This section repeats the analysis of Sect. 7.3 for the natural gas import portfolio. Table 7.6 provides the total natural gas import and production of Turkey in millions of cubic meters, through the years 2002 to 2011. The table shows that domestic production of natural gas in Turkey is rather stable through the years. However, at odds with oil imports, Turkey's natural gas imports surge by around 125 % from 2002 to 2011.

Figures 7.3 and 7.4 and Tables 7.7 and 7.8 demonstrate the dynamics of the composition of Turkey's natural gas imports is somewhat different from those of crude oil imports. First, due to more complicated natural gas logistics, number of

Table 7.6 Total natural gas imports and production of Turkey

Years	Import	Production
2002	17,624	378
2003	21,188	561
2004	22,174	707
2005	27,028	896
2006	30,741	907
2007	36,450	893
2008	37,793	1,015
2009	33,619	729
2010	32,466	726
2011	39,723	793

Source: Republic of Turkey, Energy Market Regulatory Authority (EPDK). www.epdk.gov.tr (The numbers are shown in millions of cubic meters)

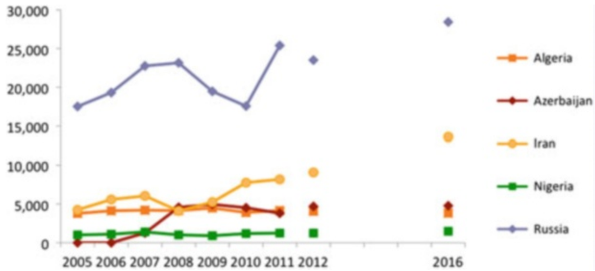
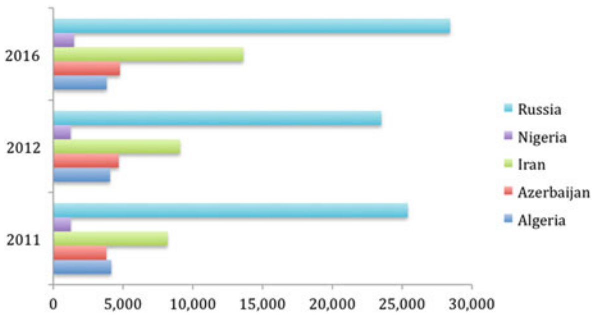


Fig. 7.3 Natural gas import portfolio of Turkey, historical data and forecast (*Notes:* The *vertical* axis shows imports in millions of cubic meters, whereas the *horizontal* axis shows the years. Forecasted values are shown as *dots* while historical imports are displayed with *solid lines*)

Fig. 7.4 Bar chart of natural gas import portfolio of Turkey (*Notes:* The *horizontal* axis shows imports in millions of cubic meters, whereas the *vertical* axis shows the years. Years 2012 and 2016 represent the forecast)



suppliers and their shares do not change dramatically over the years. Second, Middle Eastern countries do not dominate natural gas imports and Iran is the only gas supplier from the Middle East. In 2005, the share of Iran in total imports was 0.16, while in 2011 this share rose slightly to 0.19. The forecasts for 2012 and 2016 are 0.21 and 0.26. Importantly, Turkey's gas import portfolio mostly depends on

Table 7.7 Natural gas portfolio of Turkey, historical data and forecast

Countries	2005	2006	2007	2008	2009	2010	2011	2012[a]	2016[a]
Iran	3,786	4,132	4,205	4,148	4,487	3,906	4,156	4,069	3,829
Total Middle East	3,786	4,132	4,205	4,148	4,487	3,906	4,156	4,069	3,829
Import dependence on Middle East	***0.160***	***0.190***	***0.170***	***0.110***	***0.150***	***0.220***	***0.190***	***0.210***	***0.260***
Algeria	3,786	4,132	4,205	4,148	4,487	3,906	4,156	4,069	3,829
Azerbaijan	0.000	0.000	1,258	4,580	4,960	4,521	3,806	4,692	4,779
Nigeria	1,013	1,100	1,396	1,017	903	1,189	1,248	1,241	1,485
Russia	17,524	19,316	22,762	23,159	19,473	17,576	25,406	23,512	28,438
Others Total	22,323	24,548	29,621	32,904	29,823	27,192	34,616	33,513	38,530
Import dependence on other countries	**0.840**	**0.810**	**0.830**	**0.890**	**0.850**	**0.780**	**0.810**	**0.790**	**0.740**
Total	26,571	30,142	35,675	37,017	35,075	34,957	42,806	42,598	52,149

Notes: [a]Indicates the forecasted values based on the model in Sect. 7.2.1. The numbers are indicated in millions of cubic meters

Table 7.8 Current and forecasted natural gas market concentration, S_{ti}^2

	2010	2011	2012[a]	2016[a]
Iran	0.0485	0.0192	0.0457	0.0660
Total Middle East	***0.0485***	***0.0192***	***0.0457***	***0.0660***
Algeria	0.0123	0.0049	0.0088	0.0053
Azerbaijan	0.0164	0.0041	0.0117	0.0082
Nigeria	0.0011	0.0004	0.0008	0.0008
Russia	0.2484	0.1843	0.2950	0.2918
Others total	***0.2782***	***0.1939***	***0.3164***	***0.3061***

Notes: [a]Forecast based on predicted import in Table 7.7. Market concentration S_{ti}^2 is computed as the square of the market share of country i in year t. For details see Sect. 7.2.2

Russia, with this dependence slightly decreasing over years. In 2005, Russia's share in total imports was 0.66 while in 2011 its share was 0.59. As shown in Table 4.3 of Chap. 4, the forecast of market concentration of gas suppliers shows a slight increase by 2016, which is not enough to raise concern. In 2010, the market concentration for Middle East and other countries was 0.0485 and 0.2782. In 2016, these values are 0.0660 and 0.3061.

7.3.4 Geopolitical Market Concentration Risk of Turkey's Natural Gas Import Portfolio

This section is based on the model for evaluating geopolitical market concentration risk described in Sect. 7.2.2. Table 7.8 presents the current and the forecasted

Table 7.9 The geopolitical market concentration risk (GMC) of natural gas suppliers of Turkey

Country	2010	2011	2012(WC)*	2012(BC)*	2016(WC)*	2016(BC)*
Iran	0.0763	0.0280	0.0713	0.0603	0.1217	0.0871
Total Middle East	***0.0763***	***0.0280***	***0.0713***	***0.0603***	***0.1217***	***0.0871***
Algeria	0.0173	0.0069	0.0141	0.0116	0.0096	0.0065
Azerbaijan	0.0214	0.0056	0.0172	0.0153	0.0144	0.0104
Nigeria	0.0019	0.0007	0.0014	0.0012	0.0015	0.0011
Russia	0.3435	0.2532	0.4483	0.3891	0.4945	0.3693
Others total	***0.3841***	***0.2664***	***0.4810***	***0.4173***	***0.5200***	***0.3874***

Notes: For years 2012 and 2016, as indicated by *, we show the forecasted values. *WC* corresponds to the worst-case scenario, while *BC* relates to the best-case scenario. Countries scoring less than 0.0001 are not included in this table. The GMC is computed by using Eq. 7.4

natural gas market concentration, which is based on predicted imports. These values are used as inputs in Eq. 7.4.

Results in Table 7.9 show that the geopolitical market concentration risk of Turkey is increasing in both scenarios relative to year 2011 but does not change much compared to year 2010. In contrast to oil imports, the risk from the Middle East is not the major component of the total GMC risk. Here, Russia is the major source of GMC risk due to its relatively large market share. For example, in 2016 both best case and worst case scenarios predict that Russia contributes almost 95 % to the total GMC risk.

7.4 Robustness Check

To verify the reliability of our results we perform forecasts using different smoothing parameters, namely, U and V in Eqs. 7.1 and 7.2. We also show how these parameters affect the forecasts for the most influential and typical import patterns from countries with largest import shares.

On average, imports from most countries display a steady upward or downward trends that are relatively easy to use to forecast if we believe that the same trend will prevail in the future. An example of such a steady trend is shown on the upper panel of Fig. 7.5 relating to Iraq. We can conclude that in this case all methods almost agree in their predictions. However, the bottom panel of the Figure demonstrates an important exception. Iran does not belong to this group of monotonic import dynamics. Specifically, there is one major outlier in 2009, which largely affects the prediction. The forecast using U and V $= 0.3$ is the highest because the double exponential smoothing method with lower smoothing parameters puts more weight on more recent data.

To be conservative, we present and discuss all results for U and V $= 0.4$. For other cases, we report average GMC risk for the Middle East and other countries. Tables 7.10 and 7.11, Figs. 7.6 and 7.7 show that all models predict an overall increase in GMC risk for both BC and WC.

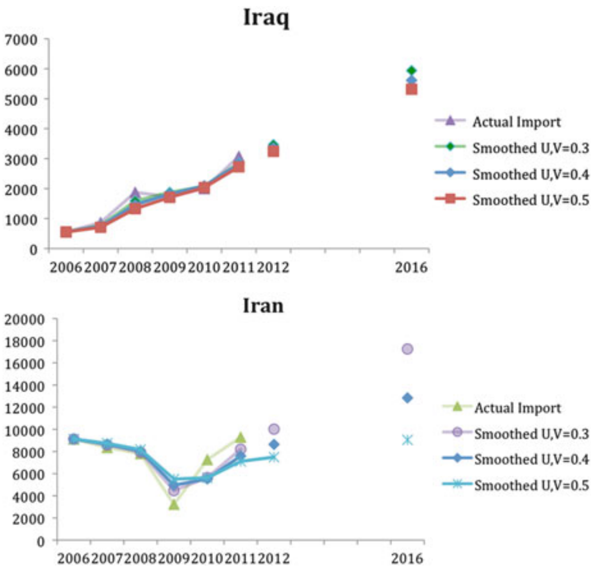


Fig. 7.5 Actual oil imports from Iran and Iraq and several versions of smoothing and forecasts (*Notes:* The *vertical* axis shows imports in thousands of metric tons, whereas the *horizontal* axis shows the years. Forecasted values are shown as *dots* while actual and smoothed values of imports are displayed with *solid lines*. "Smoothed U, V = 0.3" refers to the fitted line estimated according to the double exponential smoothing method described in Sect. 7.2.1. U and V are smoothing parameters as in Eqs. 7.1 and 7.2)

Table 7.10 Crude oil imports and GMC risk of for different forecasting models

	2011	2012 WC	2012 BC	2016 WC	2016 BC
Middle East U,V = 0.2	0.35	0.52	0.44	0.80	0.57
Other countries U,V = 0.2	0.02	0.01	0.01	0.00	0.00
Middle East U,V = 0.3	0.35	0.49	0.41	0.72	0.51
Other countries U,V = 0.3	0.02	0.01	0.01	0.01	0.01
Middle East U,V = 0.4	0.35	0.43	0.36	0.63	0.44
Other countries U,V = 0.4	0.02	0.01	0.01	0.02	0.01
Middle East U,V = 0.5	0.35	0.35	0.30	0.53	0.37
Other countries U,V = 0.5	0.02	0.02	0.02	0.02	0.02

Notes: U, V = 0.3 refers to parameters in the double exponential smoothing method described in Sect. 7.2.1. *WC* corresponds to the worst-case scenario, while *BC* relates to the best-case scenario according to the International Country Risk Guide, 2012, Current Risk Ratings and Composite Risk Forecasts. For details see Sect. 7.2.2 and Table 7.1

For crude oil, all forecasting models predict an overall increase of GMC risk from the Middle East for both the worst-case and the best-case scenarios. Iran is the major oil supplier of Turkey and higly affects the risk of its aggregate oil import portfolio, which explains higher predicted imports from Iran and thus higher GMC risk in models with lower U and V.

Conclusion

To our knowledge, a comprehensive study of Turkey's GMC risk forecast of its current crude oil and natural gas diversification portfolio has not been

Table 7.11 Natural gas imports and GMC risk of for different forecasting models

	2011	2012 WC	2012 BC	2016 WC	2016 BC
Middle East U,V = 0.2	0.03	0.07	0.06	0.09	0.07
Other countries U,V = 0.2	0.27	0.54	0.47	0.75	0.56
Middle East U,V = 0.3	0.03	0.07	0.06	0.12	0.09
Other countries U,V = 0.3	0.27	0.50	0.44	0.61	0.45
Middle East U,V = 0.4	0.03	0.07	0.06	0.12	0.09
Other countries U,V = 0.4	0.27	0.48	0.42	0.52	0.39
Middle East U,V = 0.5	0.03	0.06	0.05	0.10	0.08
Other countries U,V = 0.5	0.27	0.48	0.41	0.49	0.36

Notes: U, V = 0.3 refers to parameters in the double exponential smoothing method described in Sect. 7.2.1. *WC* corresponds to the worst-case scenario, while *BC* relates to the best-case scenario according to the International Country Risk Guide, 2012, Current Risk Ratings and Composite Risk Forecasts. For details see Sect. 7.2.2 and Table 7.1

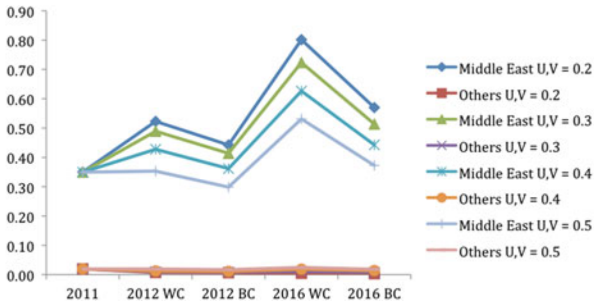


Fig. 7.6 Crude oil imports and GMC risk for different forecasting models (*Notes:* U, V = 0.3 refers to parameters in the double exponential smoothing method described in Sect. 7.2.1 *WC* corresponds to the worst-case scenario, while *BC* relates to the best-case scenario according to the International Country Risk Guide, 2012, Current Risk Ratings and Composite Risk Forecasts. For details see Sect. 7.2.2 and Table 7.1)

conducted.[3] We apply the methodology in Chatterjee (2012), which analyzes the geopolitical market risk of India's crude oil diversification portfolio, to the case of Turkey, for both crude oil and natural gas. Moreover, we extend the study by Chatterjee (2012) through several robustness checks to verify our results. We show that Turkey's crude oil and natural gas suppliers are highly concentrated to a few countries.

We conclude that Turkey's future crude oil market is forecasted to be dominated by a single country—Iran. Iran is the major oil supplier of oil to Turkey, which higly affects the risk of its aggregate oil import portfolio. From 2011 to 2016, the share of the GMC risk of Turkey's oil imports from the Middle

[3] Except for the Ediger and Berk (2011)'s study that concludes the importance of crude oil import diversification for Turkey through the principal component analysis.

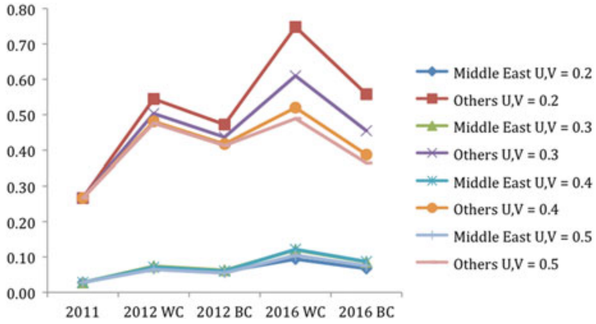


Fig. 7.7 Natural gas imports and GMC risk of for different forecasting models (*Notes:* U, V = 0.3 refers to parameters in the double exponential smoothing method described in Sect. 7.2.1. *WC* corresponds to the worst-case scenario, while *BC* relates to the best-case scenario according to the International Country Risk Guide, 2012, Current Risk Ratings and Composite Risk Forecasts. For details see Sect. 7.2.2 and Table 7.1)

East is forecasted to rise 26 % and 79 %, respectively, according to the best case and worst case scenarios. From the perspective of natural gas imports, the forecast of market concentration of gas suppliers shows a slight increase by 2016. However, once again a single country, Russia, contributes almost 95 % to the total GMC risk. We show that our results are robust to different forecasting methods.

We should point out that, our study is based on 6 years of longitudinal data versus 15 years of data in Chatterjee (2012). However, this limitation in data does not pose any drawback on our results given that the forecast based on double exponential smoothing depends on the most recent data, which is 5–6 years.

Our results underscore that for crude oil imports, Turkey must not only find suppliers from other regions, but it must also diversify its suppliers among other countries in the Middle East. The large bias towards Russia in natural gas imports also needs special attention due to the growing portion of natural gas in the overall energy sources for Turkey.[4]

Energy security is a universal concern for all countries and this methodology can be applied to the geopolitical market risk concentration of any nation's energy imports. However, a limitation of this study lies in the assumption that the pattern in past observations of crude oil and natural gas imports will also persist in the future. In other words, it is assumed that the trend in Turkey's oil and natural gas imports will not change.

[4] The share of oil in overall resources fell from 46 % in 1995 to 26.7 % in 2010, whereas the share of natural gas rose from 9.9 % in 1995 to 31.9 % in 2010. More interestingly, the share of other alternative resources (excluding coal and hydroelectric) was 12.1 % in 1995 but fell to 6.7 % in 2010.

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Re-examining Turkey's Potential of Becoming a Natural Gas Transit Hub 8

Mehmet Baha Karan, C. Coşkun Küçüközmen, and Arif Aktürk

Abstract

The aim of this study is to investigate the potential for Turkey to play a role as a natural gas hub in view of its location adjacent to the most important gas producer and energy consuming countries. In spite of the importance of the location of Turkey for the energy security of the EU, the current gas stream to Turkey and infrastructure are inadequate due to technical, political and economic factors affecting the Southeastern European energy corridor. During the last 15 years, Turkey has achieved considerable reforms in energy markets and complied with all directives of the European Union. However, Turkey still needs to adopt a more transparent framework regarding liberalization of its internal energy market. Our study shows that Turkey should not only improve her market structure, but also continue to develop new projects that will improve her position in the competitive world energy environment. Turkey is in a key location in this international game: in addition to the current BTE pipeline, TANAP is the most promising pipeline passing through Turkey in the east–west energy corridor. A SWOT analysis reveals many factors that favor Turkey as the major European natural gas transit hub. However, many obstacles that may hinder the achievement of its full potential remain.

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8.1 Introduction

About 80 years ago, the famous Turkish poet Nazim Hikmet described the location of Turkey as “Galloping from farthest Asia, / jutting into the Mediterranean like the head of a mare, / this country is ours”.[1] Hikmet’s verse reflects not only the position of Turkey as a natural bridge between continents, but also her historical and economic relations with her developing Asian and wealthy European neighbors. Turkey currently is becoming a connection point for commodities and energy trade on a route that corresponds to the historical Silk Roadand that has been regaining importance since the 1990s. This is particularly true for the natural gas trade, which is entering its golden age (IEA 2011). The European Union (EU), which has only 2 % of the proven natural gas reserves of the world, consumes 17 % of the world’s gas production. The proven gas reserves of Turkey’s neighboring countries, i.e., Iran, Russia, Azerbaijan, Turkmenistan, Uzbekistan and Kazakhstan, are 47 % of global gas reserves (BP 2011).

The importance of Turkey in the energy trade depends not only on her geographic location, but also her role in international trade through the Bosphorus and Dardanelles straits; ties with the EU; and strong historical relations with Central Asia and the Islamic countries in the Middle East. Turkey is regarded as a stable and democratic state in the region as a member of NATO and a strategic partner of the U.S. Finally, Turkey is one of the world’s highest energy consumers. In addition to potentially becoming the fourth European energy corridor for Europe and increasing the bargaining power of Europe by allowing it to by-pass Russia, these assets can turn Turkey into an important regional gas hub in the competitive worldwide gas market.

Since the beginning of the 2000s, to further its progress towards becoming a regional energy hub at the south-west corridor of Europe, Turkey has followed the energy directives of the EU and has implemented significant reforms in the energy sector, and also has developed several pipeline projects. Turkey’s energy sector has been transformed from a monolithic, state-run entity to a commercially-run, liberalized market, with significant private investment and ownership (World Bank 2012). Furthermore, the current and potential natural gas projects have placed Turkey in a key position in the energy security of Europe.

However, the experience of various pipeline projects over the last decade showed that this privileged location is not in itself enough for Turkey to become an energy route or hub. Factors such as the instability of the region, the shadows of the heritage of the Ottoman Empire, and the competing political goals of the U.S., Russia and Iran, make the situation more complex. These factors require intelligent energy policies that are flexible and comprehensive.

The aim of this study is to reexamine, from a political economy perspective, Turkey’s location as a transit hub in the east–west corridor of Europe, and to

[1] “The Horseman’s Song,” *Selected Poetry of Nazim Hikmet*. Translations by Randy Blasing and Mutlu Konuk.

describe the relevant reforms, projects and opportunities. Using SWOT analysis, we demonstrate Turkey's potential and discuss her current and potential bargaining power.

This study has six sections. Following the introduction, in the Sect. 8.2 we discuss Turkey's location as a natural gas hub. In Sect. 8.3, we present Turkey's current energy policy and the market structure of natural gas. In Sect. 8.4, we analyze the newly-proposed and projected pipelines passing through Turkey in the east–west energy corridor. In Sect. 8.5, we re-examine Turkey's potential to become a transit hub we. Section 8.6 concludes the paper.

8.2 The Location of Turkey as a Natural Gas Energy Hub: A Political Economy Perspective

Reports on the east–west gas corridor of Europe generally view Turkey as a natural bridge between countries supplying gas and countries consuming gas and confirm her natural advantage in the gas trade (Winrow 2009; Eissler 2012). A simple technical and financial analysis may also verify these arguments. However, considering the complicated political relations and the competition among the major powers of the region, relying on purely economic approaches while ignoring political economy perspectives would not be appropriate.

8.2.1 Gas-Supplying Countries and Their Complicated Political Relations

The known natural gas reserves worldwide are estimated to be around 400 trillion cubic meters, based on current technology and economic conditions. This is equal to more than 120 years of current annual production. Global natural gas resources are vast and widely dispersed geographically, but half of the world's proven reserves are concentrated in Russia, Iran and Qatar (IEA 2011). As shown in Fig. 8.1, Azerbaijan, Turkmenistan, Kazakhstan, Uzbekistan and some other Middle East countries also have considerable proven gas reserves. In contrast, the part of the gas resource considered as unconventional, has traditionally been too difficult or costly to produce.[2] However, these sources of gas are now considered to be as large as conventional resources and represent 16 % of global gas production as of 2011. The increase in unconventional gas production in 2011 came mostly from North America, where shale gas continues to boom (IEA 2012b). Although Europe has a significant shale gas potential, a production boom is not expected in the

[2] The main types of unconventional gases are shale gas, coal-bed methane, tight gas and gas hydrates. Shale gas is natural gas contained within a commonly occurring rock classified as shale. Coalbed methane, also known as coal seam gas in Australia, is natural gas contained in coalbeds. Tight gas is a general term for natural gas found in low permeability formations. Gas hydrates are methane trapped in marine sediments as hydrate.

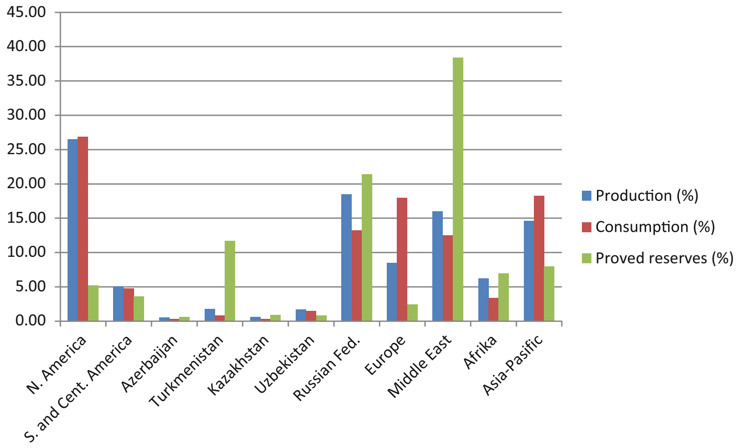


Fig. 8.1 Percentage of world's proved natural gas reserves and natural gas consumption – production (Source: *BP Statistical Review of World Energy*, June 2011)

coming years due to environmental concerns. It is estimated that Turkey may have 15 trillion cubic meters of technically recoverable shale gas reserves (EIA April 5, 2011).

The production base of natural gas is concentrated in only three regions worldwide; North America, Russia and the Middle East (primarily Qatar and Iran). Turkey is close to the latter two regions. This pattern of production is not expected to change significantly in the next decade. Political considerations and individual country depletion policies play at least as great a role in global gas resource development as geology and economics, and will dominate the evolution of the global gas market (MIT 2010). In addition, the development of transportation facilities and pipelines that require considerable international coordination and investment are playing a significant role in gas production and trade between countries.

Turkey's relations with energy supplying countries are well-established, with many common linguistic, religious, historical and cultural ties. However, there also exist varying degrees of religious, political and economic tensions. Thus, from Turkey's perspective, neighboring countries can be categorized into five groups: the Russian Federation, Central Asia, Iran, the Middle East and Azerbaijan (Table 8.1).

Turkey and Russia have had significant problems and disagreements over the last 300 years. Currently, however, relations are more stable than ever. The countries have established a regular political dialogue and Russia has become the largest trading partner and the main energy supplier of Turkey. Russia not only supplies 58 % of Turkey's current natural gas needs, but is also building the first nuclear plant in Turkey. In spite of this reconciliation, both countries are competing to influence countries in the Middle East and Central Asia to gain a larger share in the international energy trade. Turkey's economic relations with Central Asian countries, particularly with Turkmenistan and Kazakhstan, have developed rapidly and, after the collapse of the Soviet Union, significant progress has been achieved in

Table 8.1 Countries supplying natural gas to Turkey

Supplying countries	Connection	Capacity/ year	Current status	Remarks
Russia	Blue stream	16 bcm	Operating	Causes overdependence on Russia
	West gas pipeline	14 bcm	Operating	
Turkmenistan and Kazakhstan	No current connection with Turkey		Projects under development	Turkmen and Kazakh gas supplies may connect with TANAP project in a decade
Iran	Tabriz Ankara Pipeline	10 bcm	Operating	The nuclear program of Iran is a significant barrier to developing new projects
Arabic countries	Arab pipeline	4 bcm	The contract is signed	Delayed due to lack of gas supplies and political reasons
Azerbaijan	South Caucasus Pipeline (BCE)	6.6 bcm	Operating	Relations to be developed further with the TANAP project
Algeria and Nigeria	LNG	5.2 bcm	Operating	Turkey has two LNG terminals and a limited amount of storage capacity

the fields of energy, trade, transportation and communication. However, Russia's continuing influence on these countries should be acknowledged. Russia, with its desire to control the supply of energy, continues to dominate political decision-making throughout Central Asia. New pipeline projects in the newly independent countries of Central Asia can be seen as efforts to break free from the influence of Russia. A particular example in this regard is the Trans-Caspian project, which is expected to supply 20–30 billion cubic meters (bcm) of Turkmen gas over a decade to the Trans Anatolian Project (TANAP) pipeline that was designed to connect Azerbaijan and Europe. It should be noted that in 1999 Turkey and Turkmenistan had already signed a 30-year agreement on a 16 bcm gas pipeline. Kazakhstan[3] has similar expectations (UPI Sep. 5, 2012).

The relationship between Turkey and Middle Eastern countries depends on religious and historical ties. However, complicated relations and endless conflicts remain as important barriers. Currently, the only natural gas project involving Turkey and Arab countries is the Arab pipeline that exports Egyptian natural gas to Jordan, Syria and Lebanon, and that is planned to connect with Turkey. However, developments after the Arab Spring and limited gas supplies in Egypt have presented difficulties (Gulfnews.com, Dec 3, 2012). The recent discovery of Cypriot and Israel natural gas reserves in the Mediterranean may force Ankara, Athens and Tel Aviv to normalize their relations. Considering the logistic

[3] A Turkish gas company (Bosphorus gas) which have a link with Gazprom applied to EMRA to bring Kazakh gas (0.75 bcm) to Turkey through Russia via pipeline.

advantage of Turkey, Israel and Greece may ultimately be pressured to cooperate with Turkey for their long-term interests (Wagner and Cafiero 2013).

In Iraq, where the International Energy Agency predicts expanding oil production in the next decade, conflicting interests complicate relationships (IEA 2012a). Turkey is blocking an independent Kurdish State in Northern Iraq, while simultaneously developing economic relations with the Kurdistan Regional Government (KRG). Currently, the KRG, which seriously disagrees with the central government of Iraq, aims at supplying 15 billion cubic meters of natural gas to Turkey (Kurdpress Dec. 16, 2012).

Iran and Turkey have close trade and economic relations. Turkey imports up to 10 billion cubic meters a year of gas from Iran, which is nearly 20 % of the country's total needs.[4] The Tebriz-Ankara pipeline offers Turkey opportunities to capitalize on the exportation of energy sources from Central Asian countries to markets in Europe. However, UN restrictions and U.S. sanctions due to the nuclear program of Iran are the main barriers to the gas trade between the two countries. Further, Turkey has partly refused to participate in the West's campaign to isolate Iran economically (Wagner and Cafiero 2013).[5]

Politically and economically, the relationship between Turkey and Azerbaijan is very strong. The initial capacity of the South Caucasus Pipeline (BTE), which connects Azerbaijan and Turkey via Georgia, is 6.6 bcm of gas per year. Both countries also are attaching great importance to a new project, The Trans-Anatolian gas pipeline (TANAP), which will connect Azerbaijan to the EU through Turkey.

The Turkish Electricity Transmission Company estimates that demand for electricity will increase at an annual rate of 6 % between 2009 and 2023 (Turkish Investment Agency 2012). In 2010, 46.47 % of electricity consumed in Turkey was provided by gas-fired powered plants (Indexmundi 2012). Thus, current natural gas imports are hardly sufficient for domestic consumption and supplies are supplemented in a flexible way by LPG imports from Algeria and Nigeria using two local terminals to sustain the growth of the installed power generation capacity.

8.2.2 Natural Gas Demand and Energy Security of European Countries

High consumption and low production levels of natural gas in member countries complicate the EU's energy policy. It is forecasted that the domestic natural gas production of the EU will decrease from 2,019,286 to 1,312,001 GWh during 2011–2020 (Deloitte 2012). In addition, in the last decade dependence on non-member countries for supplies of natural gas has grown at a faster pace than dependence on crude oil, which already was at a high level. Furthermore, the current community

[4] Due to technical problems, Iran cannot produce sufficient gas to export to Turkey and currently is importing gas from Turkmenistan to re-export to Turkey (*LNG World News*, Nov 21, 2012).

[5] More than 2,000 privately-owned Iranian firms are operating in Turkey.

mechanism is inadequate to guarantee a timely response to any natural gas supply crisis at the community-level. About four-fifths of EU gas imports arrive from three corridors, Russia, Norway and Algeria, while the remaining imports are in the form of LNG.[6] The dependence of Europe on Russia, which supplies about 40 % of natural gas consumed, has become an extremely controversial issue among EU Member Countries (Noël 2008). Critics emphasize the inadequate common energy policy of the EU and the monopoly power of Russia. The alternative fourth corridor through Turkey is a potential solution to the issues of long-term gas supply availability and diversity, as well as a way of addressing wider European geopolitical interests, such as consolidating central Asia's political and economic independence from Russia (Noël 2008).

One consolation for Europe is the expected slowing of the rate of consumption in coming decades. According to the "golden age" gas scenario of the IEA, annual demand for gas will increase by only 0.7 % during the 2008–2035 period. However, no golden age of natural gas is expected for Europe in contrast to America and Asia. Likely, European gas demand will probably be affected by low economic growth, which reduces the rate of increase of demand for power and weakens the industrial sector, leading to higher gas prices and stronger growth of renewables (IEA 2012b). Nevertheless, the report also indicates that natural gas, which is preferred over nuclear energy, will be a significant and indispensable source of energy for Europe in the long term. In this scenario, the cost advantage and low carbon dioxide emission of natural gas play an important role.

Turkey has long-established historical links with European countries and currently is a very important trade partner and has a strong desire to join the European Union. Although both parties are not optimistic as to the outcome of the partnership negotiations, they are determined to maintain their relations. Considering Russia's political ambition, from an EU perspective, Turkey is a preferred trade partner over Russia. Currently, Turkey plays an insignificant role in supplying gas to European countries. However, the Nabucco and other pipeline projects have the potential to change this situation (McDonald 2010).

The EU's approach to the goal of a single market became more crystallized in the last 10 years, and the third energy package routed [not clear about what is meant by "routed"] this objective by providing more detailed sanctions (Karan and Kazdagli 2011). Market integration and the consolidation of regional organized markets would result in eliminating the existing price differences among regions of the EU through greater transparency and increased competition and efficiency. It is also expected that efficient market integration will facilitate access to alternative natural gas sources, such as the Caspian and Middle East, through Turkey. The European Union gives particular importance to the south-eastern part of Europe,

[6] Currently, the LNG market is one of the fastest growing parts of the energy business. Since LNG needs significant amount of infrastructure investments, suppliers are transporting LNG along routes and in areas where it is not economically viable to construct a pipeline. Qatar, Malaysia, Indonesia, Australia and Algeria, which are the main producers of LNG, sell about 25 % of their production to Europe- and most of the rest of their production to Japan and Asia.

which has political and economic constraints. Therefore, the fourth corridor with an additional regional gas hub, which contributes regional market integration in this area, will be a very important asset in reducing the energy dependency of the whole community (Laczkó and Lajtai 2009).

8.3 Turkish Energy Policy and the Domestic Natural Gas Market

8.3.1 Energy Market Reforms

As in most western countries before 2000, the energy market of Turkey was under total state control and two major state companies had monopoly power in the electricity and gas markets. A turning point for the Turkish energy policy came with the Helsinki Summit in 1999, when Turkey was accepted as a candidate. After this time, the reforms that were implemented lead to restructuring and a more efficient and competitive energy policy based on EU directives. Following the Electricity and natural Gas Market Law (2001), the independent market regulatory agency (EMRA) has been established and competition-oriented mechanisms have been implemented.

The main purpose of the new legislation is to launch a legal structure for developing a transparent and competitive natural gas market by separating market activities and reforming the state gas company, Botaş. This includes loosening the company's vertically integrated structure. According to the new legislation, Botaş has been obliged to offer their infrastructure to other players of the market. After the Petroleum and LNG Law (2005), a number of other laws were adopted to diversify and develop the Turkish energy market. These were the laws on the Utilization of Renewable Energy Sources (2005), the Energy Efficiency Law (2007) and the Law on Construction and Operation of Nuclear Power Plants and Energy Sale (2007). The six main aims of the regulatory reforms were as follows: (i) to introduce and to institutionalize competition in the market, (ii) to expand the network of gas transmission pipelines within the country, (iii) to construct new gas distribution networks for all the cities in the country, (iv) to increase the use of natural gas, (v) to diversify the natural gas sources for security of supply reasons, and (vi) to develop transit infrastructure between the suppliers in the Caspian Sea and the Middle East, and the consumers in Europe (Atiyas et al. 2012).

The electricity sector of Turkey has become unbundled. Currently, the transmission, generation, distribution, wholesale trading, retail supply activities of the government company are privatized and separated. Turkey has taken significant steps to creating competitive wholesale and retail electricity markets by establishing a 'day-ahead' electricity market, balancing mechanisms and developing electricity futures contracts. However, this progress is not reflected in the natural gas sector. Eventually, Botaş will be restructured into separate legal entities that will handle the import, storage, trade and transmission of natural gas and, with the exception of transmission, all separate business segments will eventually be fully privatized. However, the company still continues to control nearly 85 % of the wholesale market (IEA 2009).

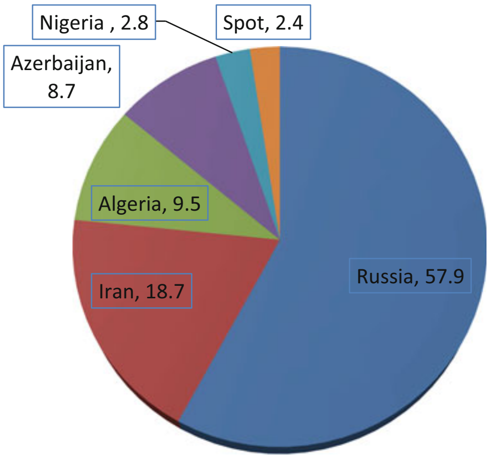
Initially, there were concerns about over-supply in the Botaş contracts and over-dependency on Russian gas, which lead the parliament to enact some temporary legislation to prohibit additional imports from those countries in which Botaş has natural gas sales and purchase contracts. Moreover, to ensure fair competition, the company has been obliged to transfer its bilateral long-term contracts to third parties. However, the process that will allow the transfer of purchase contracts from Botaş to private companies, which was agreed in 2008, is still incomplete. In addition to these legal problems arising from intergovernmental agreements, political problems also make it difficult to increase natural gas imports. Another problem is the subsidized pricing policy, mandated by the government, that forces the company to price natural gas to the domestic market below its cost and that makes it difficult for competitors to import LNG at a competitive price.

8.3.2 The Domestic Natural Gas Market

Turkey started to import natural gas at the end of the 1980s and its usage has increased rapidly since then. According to EMRA, the annual natural gas consumption in 2011 was 43.6 bcm and increased to 48 bcm in 2012. The annual rate of increase is expected to reach 4.6 % by 2020, then fall to 2.3 %, depending on developments on supply diversification. Thus domestic natural gas production of Turkey is not even able to meet 2 % of her needs. However, Turkish Petroleum Company (TPAO) has started exploring shale gas in Turkey with Royal Dutch Shell Company (Seeking Alpha, Sept 5, 2012).

The main suppliers of gas to Turkey are Russia, Iran and Azerbaijan (via pipelines) and Nigeria and Algeria (LNG). Figure 8.2 reveals that Turkey is overly dependent on Russian gas. The most remarkable characteristic of the Turkish energy market is the high share of natural gas used for electricity generation as the primary energy source, which accounts for about half of the natural gas consumption. Therefore, the two main factors in Turkish electricity prices are the cost of gas and the high annual rate of increase (6–8 %) in demand, (Deloitte 2012). Considering that under the existing long-term contracts the supply capacity, will reach 47.8 bcm/year by the end of 2014, serious problems in supply and demand balances are expected because Turkey has limited operational storage facilities in the short-run. Overdependence on natural gas, insufficient diversification, and poor storage capacity with seasonally volatile gas demand are the main concerns. Supplier or transit countries could restrict volumes for economic or political reasons, as in the cases of Ukraine in 2006, and Iran in January of 2007 and 2008 (Atiyas et al. 2012).

Fig. 8.2 Gas imports of Turkey according to countries (2011) (Source: EPDK 2012)



8.4 Analysis of Newly Proposed and Projected Pipelines Stretching Through Turkey in the East–West Energy Corridor

The specific features of gas as a regional commodity and the European context which is characterized by the patterns of decreasing production, rising consumption and the highly concentrated supply (Nicolò Sartori 2012) make the natural gas sector of the EU particularly subject to security concerns. The EU's dependence on Russian natural gas imports was the motivation for the creation of a Southern gas corridor to connect with Middle East and Central Asia's immense reserves. The first of these pipelines was the Nabucco project from the eastern border of Turkey to Austria, diversifying natural gas suppliers and transportation routes for Europe (Fig. 8.3). The project was supported by European Union states and the United States. In 2002, Turkey, Bulgaria, Romania, Hungary and Austria agreed to build the Nabucco pipeline to avoid reliance on Russia. The main supplier was expected to be Iraq, with further potential supplies from Azerbaijan, Kazakhstan, Turkmenistan, and Egypt (and possibly Iran). The project was being developed by a consortium of six companies.[7] If built, the pipeline was expected to be operational by 2017 with a length of 3,893 km (www.nabucco-pipeline.com).

The Nabucco project's estimated cost was $15–$20 billion and tariff calculation of the project aimed at a required and planned profitability in terms of return on investment. The period of calculation amounts to 30 years (long-term contracts); comprising a 5-year pure construction period plus 25 years of operation. The basic assumption of the project was that the commitments of gas would be fully realized during the operating years. The lenders finance the construction of the system for the transportation of up to 15.7 bcm per year. In order to obtain a reasonable

[7] OMV (Austria), MOL (Hungary), Transgaz (Romania), Bulgargaz (Bulgaria), BOTAŞ (Turkey) and RWE (Germany) and each of the shareholders holds 16.67 % of the shares.

Fig. 8.3 The natural gas pipeline projects in the East West energy corridor (Source: The map is modified by the authors using the original Google map as a background)

tariff, the total demand for 2021 must exceed 25.5 bcm. This amount of booked capacity was crucial in order to ensure the bankability and viability of the Nabucco project and to secure a reasonable unit tariff for transportation. The operating cost of the project was estimated to be 3 % of initial capital investment. The debt service ratio (cash flow available for debt service/[interest and principal payments]) was the major ratio used by lenders and was expected to average 1.5, and the expected internal rate of return of the project was projected to be 13 % (www.nabucco-pipeline.com). It is assumed that the alternative projects in the region will have similar financial objectives.

However, the main obstacle of the project was its uneconomical nature, because there was no guarantee that there would be sufficient gas supplies to make it profitable (France 24, 2009). The partners of Nabucco are the downstream players (i.e., gas consumers in the route of Nabucco). However, there is no upstream player to take the upstream risks by investing in the gas fields. In addition Nabucco faced additional barriers and problems due to political instability in the region. These include the Russian "veto" on Georgia's participation in the project, political conflicts between Azerbaijan and Turkmenistan, the two main suppliers' potential future military operations against Iran, and lack of interest and political support from transit states (Tashjian 2012).

To keep control over energy routes and as an alternative to rival the Nabucco pipeline, Russia proposed the South Stream Project in 2006. The project involves constructing a second section of the Blue Stream pipeline below the Black Sea to Turkey and extending this through Bulgaria, Serbia, Hungary and Slovenia to Austria and Italy. The offshore pipeline of the project is planned to carry 63 bcm natural gas in a year. The length of the offshore section is planned to be about 1,000 km and the expected initial investment in the South Stream pipeline is $25–$31 billion, which includes the construction of the off-shore section at a cost of $11 billion (http://www.south-stream.info/en/pipeline). This long off-shore section will raise the operating cost of the project.

Some experts point out that the higher cost of the South Stream project, which is double that of Nabucco, indicates that it is a political project assigned to counter Nabucco and to expand Russian influence in the region (Pronina and Meric 2009). In fact, the South Stream is not a new source for Europe. It was planned previously and aims to bypass Ukraine by off-shore pipelines in the Black Sea using the continental shelf of Turkey. It is likely that only 15 bcm of new additional gas supply will be transported in the long run. In spite of Turkish discomfort in the project, she could not reject it due to various integrated political and economic interests with Russia. Moreover, Turkey expects additional gas supply from South Stream, and Russia attaches importance to Turkey as the second largest gas customer whose importance may rise as demand from the EU decreases.

Lajtai et al. (2009) examined and compared the viability of both the Nabucco and the South Stream projects according to political, economic, social and technological aspects. They observed that Nabucco would decrease the gas supply dominance of the Russian Federation in Central and Eastern Europe. Nabucco involves producer countries with higher political risks, thus increasing diversity. However, its scale is not sizeable enough to significantly improve the substitutability of the current supply sources. On the other hand, South Stream would support security of supply via transit route diversity by transporting Russian gas by-passing the Ukraine. It would notably improve the supply and demand balance due to its larger scale. However, the EU's dependency on Russia would increase significantly. The major obstacle to Nabucco's implementation stands in the securing of gas supplies, while South Stream strives to secure its financial viability.

The problems associated with Nabucco and competition among pipeline projects aspiring to bring Caspian gas to the European market have led Azerbaijan and Turkey to create a new group of co-dependent plans; these are the TANAP and TAP/Nabucco West projects. The Trans-Anatolian gas pipeline (TANAP) is a proposed natural gas pipeline from Azerbaijan through Turkey to Europe. It is designed to transport gas from the second stage of the Shah Deniz gas field. TANAP, a pipeline introduced after the Nabucco project, will have a significant effect on the transportation of Caspian gas to Europe and, unlike its competitors, is assured of sufficient supplies (Fig. 8.3).

Azerbaijan expects gas production to reach some 50 bcm of gas annually by 2025 (double the present annual production). In addition to Shah Deniz, this increase is anticipated to come from the Apsheron, Umid, Babek, deep-water ACG, and possibly Shafak-Asiman projects, all of which involve international companies in partnerships with Azerbaijan. Azerbaijan is the main gas supplier and shareholder of the TANAP project, whose total cost is estimated at 7 billion USD. Twenty percent of the project is owned by SOCAR, 51 % by BP, Statoil and Total, and 29 % by two Turkish companies, Botaş and TPAO. The pipeline capacity is projected at 16 bcm annually in the first stage, possibly rising to 32 bcm in the second stage (http://www.tanap.com/). However, the conflict between Azerbaijan

Table 8.2 The comparison of natural gas pipeline projects in the East–west energy corridor

	TANAP	TAP	Nabucco West	South stream
Length	2,000 km	780 km	1,300 km	3,700 km out of 1,000 km offshore section
Capacity (yearly)	16 bcm and may increase to 32 bcm with Turkmenistan gas	10 bcm (max 20 bcm)	10 bcm (max 31 bcm)	63 bcm
Potential sources	Shah Deniz 2 fields, Azerbaijan and Iraq gas will also be possible			Russia, Central Asia, Azerbaijan Investment
Investment cost	USD 7 billion	USD 5 billion	USD 10 billion	USD 25–31 billion
Key project sponsors	Azerbaijan and Turkey	European Union	European Union, USA	Russia
Main purpose	Increase political and commercial power of Azerbaijan and increase the potential of Turkey as a transit hub	Reduce dependency on Russian Gas		To reduce the dominance of transiting countries, such as Ukraine To increase the influence of Russia on Europe
Transit countries	Azerbaijan, Georgia, Turkey	Turkey, Greece, Albania, Italy	Turkey, Bulgaria, Romania, Hungary, Austria	Russia, Bulgaria, Serbia, Hungary, Austria, Slovenia, Greece and Italy
Companies involved	SOCAR, BP, Statoil, Total, BOTAŞ, TPAO	Axpo, Statoil and EON Ruhrgas	OMV, MOL, Transgaz, Bulgargaz, BOTAS, RWE	Gazprom, Eni
Current status	Azerbaijan and Turkey signed an intergovernmental agreement on TANAP for implementation in June 2012	Not clear. Waiting for a decision by Shah Deniz Consortium	The project is abandoned by Shah Deniz Consortium on June 25, 2013	Italy, Bulgaria, Serbia, Hungary and Greece have signed the project-related intergovernmental agreements
Planned launch date	2017	2017	2017	2015
Main risks	The initial version of TANAP did not cover the sensitive issue of status of the Caspian. However, the attempt to develop TANAP in cooperation with Turkmenistan gas, and include other	The reduction of gas consumption in Italy as a result of the financial crisis	The route is shorter than the original Nabucco project, but more expensive than TAP Threats from the new gas reserve discoveries on the Romanian coast	High investment and operation costs due to the offshore section Diversification is route only, not source

(continued)

Table 8.2 (continued)

	TANAP	TAP	Nabucco West	South stream
	sources in Nabucco may produce negative reaction from Russia, Iran, and China			
Main advantages	Good relation between Turkey and Azerbaijan	High storage capacity in Albania	High gas consumption along the route	Strong Russian support

Source: http://www.tanap.com, www.trans-adriatic-pipeline.com, http://www.south-stream.info/en/pipeline/, www.nabucco-pipeline.com and Lajtai et al. (2009)

and Turkmenistan over Caspian Sea reserves may delay the second step of the project (*The Journal of Turkish Week*, August 10, 2012).

According to the intergovernmental agreement, Botaş committed itself to purchase and transport to Turkey 6 bcm of natural gas which initially makes the TANAP project viable. TANAP will enable Azerbaijan to export its own gas to European customers directly through its own pipeline for the first time through Turkey's border with the EU (Punsmann 2012). In addition, Azerbaijan will gain access to multiple buyers, multiple pipelines and multiple transportation routes. As a result, the TANAP project will provide Azerbaijan a significant presence in the European gas market. Furthermore, the TANAP project will give Turkey an option to purchase all of the natural gas to fulfill her domestic needs, and allow re-export to international energy markets, thus supporting Turkey's role as a transit hub to Europe (Table 8.2).[8]

By the end of 2011, several mutually exclusive options were being proposed. In addition to the original Nabucco project, the Italy-Turkey-Greece Interconnector (ITGI), the Azerbaijan-Georgia-Romania Interconnector (AGRI), the Trans Adriatic Pipeline (TAP), the South East Europe Pipeline (SEEP), TANAP and White Stream were also under the consideration (European Commission 2009a). Even though initial reevaluations favored the SEEP and TAP options, the Nabucco option became more realistic following revisions made to the plans in March 2012 (Martin 2012). The SEEP project was the last option to be eliminated from the selection process when, in June 2012, the consortium operating the Shah Deniz field favored the Nabucco West option (Petroleum Economist 2012). SEEP, a lower cost and lower capacity export option extending from Bulgaria to Central Europe, was then abandoned by BP which is the initial backer of project (Financial Times 2012).

In the second stage there were two realistic proposals to connect Shah Deniz to the western markets; TAP and Nabucco West. The route of TAP is planned towards Southern Europe. Led by Statoil, TAP is projected to transport about 10 million bcm natural gas annually from Greece via Albania and the Adriatic Sea to Italy and

[8] Currently Turkey is importing 6.6 bcm gas from Azerbaijan via South Caucasus Pipeline (BCE) and re-exporting 0.75 to Greece using Turkey–Greece pipeline.

then into Western Europe. Nabucco West is a shorter version of the Nabucco project and runs from the Turkish-Bulgarian border to the vicinity of the gas hub at Baumgartner near Vienna, Austria, and passes through Bulgaria, Romania and Hungary (European Commission 2009b, c).

NabuccoWest was supported by a 50-year intergovernmental agreement between the main partners of the original project. The feasibility of the base case was not affected by the Nabucco West proposal and the total length of the pipeline, whose projected cost is USD 7 billion, will be 1,300 km and the initial planned capacity is 10 million bcm annually. Both routes can reach to the major market of EU in Germany which is beyond to their final destinations (www.nabucco-pipeline.com).

The comparative figures of the projects given in Table 8.2 reveal that TAP has a cost advantage over Nabucco West. In fact, both have advantages and disadvantages. Nabucco west would need additional investment to reach Germany, which is the largest gas market in Europe. Although this is an important drawback for the combined Balkan countries, which also are the target of Nabucco West, these countries can guarantee a solid market for the first 10 bcm of projected gas and at prices approximately 10–15 % higher than in Germany. However, the new discoveries on the Romanian coast of the Black Sea might limit the ability of the market to absorb gas from Nabucco West (naturalgaseurope, Feb 23, 2012). In contrast, the main market of TAP is Italy, which is the second biggest market in Europe, and is also able to provide two-way gas flows into Germany using current pipelines. In addition, TAP envisages physical reverse flow of up to 80 % and the option to develop natural gas storage facilities in Albania to further ensure security of supply. The cost of gas on the Italian hub is 10 % higher than in Western Europe and around 5 % higher than Baumgarten (European Commission, Quarterly Report on European Gas Market 2011). However, this benefit is countered by the reduction of gas consumption in Italy as a result of the financial crisis.

Eventually, BP-led Shah Deniz consortium preferred the Trans Adriatic Pipeline (TAP) project over Nabucco West to transport Azeri gas to Europe and cited higher gas prices in Italy and Greece as justification on June 25, 2013. From Turkey's perspective, the end of Nabucco had more political impact than economic impact. Nabucco was considered an possibility to develop its ties with EU at the beginning of 2000s. The success of Nabucco could represent for Turkey an opportunity to redefine the Eurasian energy game, where transit countries do not have any significant influence in oil and gas pipeline projects' decision-making processes (http://www.naturalgaseurope.com/impact-trans-adriatic-pipeline-selection-turkey).

Currently, considering the relatively higher import price of Turkey from Russia and limited re-export possibilities, it is not easy to place Turkey in the winner's group. The only consolation of Turkey is its share in TANAP project and TANAP's potential opportunities. However, it is clear that Russia is the winner of the game at this stage. Russia drove away Azeri gas from central Europe and strengthen his monopoly in the region by discounting the price of natural gas to northern Europe. Azerbaijan, BP, Greece, Italy and European Union are the other winners of the new decision, they all improved their position.

8.5 Re-examining Turkey's Potential of Becoming a Transit Hub

The significance of Southeastern Europe as a European energy hub is one of the most debated issues of the EU. This hub, where the energy market is relatively less developed, will not only be important for European energy security, but also for the future competitiveness of the EU energy market. Currently there are several political and regulatory efforts in place to develop efficient and competitive energy hubs in Europe.[9] The third legislative package of the EU suggests a bottom-up approach and considers regional gas hubs as effective tools for market development and integration (Everis and Mercados 2010). However, considering the political situation and the diverse physical environment in Europe, legislation alone may not be sufficient to reach the target (Heather 2012). According to the report of the Office of Gas and Electricity Markets (Ofgem), the target model for the gas market should be assessed according to the following criteria: (i) promotion of efficient use of cross-border capacity, (ii) impact on long-term contracts and on investment incentives upstream, (iii) promotion of liquid trading and transparent spot prices, (iv) impact on the role of TSOs, and (v) ease of implementation (Moselle and White 2011).

Although the international players are seeking an appropriate location for a Southern European transit hub with these factors in mind, no clear decision has yet been made. Currently, given its geographic position and the connection of its natural gas infrastructure with natural gas exporting countries, Turkey plays a key role in these debates. However, Bulgaria, Greece and Italy are also potential candidates with a strong desire to take on this mission. Bulgaria is still a transit country between Russia and Turkey and expects to have an interconnector with both Greece and Romania within the next few years. It is commonly believed that, South Stream will increase the importance of Bulgaria. The interconnector between Turkey, Greece and Italy (ITGI), the TAP and West Balkans Pipeline projects have promoted Greece as a transit gas country hub serving as a transit route for Azerbaijani gas into Central Europe. Finally, Italy receives gas from Algeria and Libya, and is able to organize two-way gas flows into Germany, and Italy's position will undoubtedly be enhanced by the TAP project (Roberts 2010). Table 8.3 indicates that Turkey, with potential sources and a strategic location, has some advantages over the other countries and those should not be underestimated. Roberts (2010) emphasizes Turkey's central position in the international exchange, and there are many factors operating in favor of it becoming one of the world's great energy hubs. On the other hand, there also are many factors which may cause it to fail to fulfill this goal.

In the competitive and ambiguous political conditions, the vision of Turkey will require significant time, local legislation and market reforms. Depending on

[9] The Council of European Energy Regulators (CEER), The Agency for the Cooperation of Energy Regulators and the European Networks Transmission System Operators (ENTSOG) are three main bodies overseeing and implementing the legislations.

Table 8.3 The candidate countries for South-Eastern Europe energy hubs

Countries	Sources (Existing and projected)	Existing projects and connection points	Potential projects and connection points	Customers	Trading environment
Turkey	Russia, Azerbaijan, Iran, Iraq, Egypt, Turkmenistan. Algeria, Nigeria, Qatar and other LNG sources	Blue Stream	TANAP	Greece, Bulgaria, Balkan countries, Southern and Central Europe, and particularly domestic demand	Developing at moderate level
		Iran Turkey pipeline	TAP		Spot Electricity Market
		Azerbaijan Turkey pipeline	Arabia Pipeline		Derivative Energy Instruments
			Iraqi Gas		
		Turkey-Greece Pipeline	Turkmenistan Turkey Pipeline		New Capital Market Law and work on new gas exchanges
		Russia, Bulgaria-Turkey pipeline			
		Two LNG terminals and potential three new ones			
		South Caucasus Pipeline			
Bulgaria	Russia and Azerbaijan Algeria, Nigeria, Qatar and other LNG sources	Russia, Bulgaria-Turkey pipeline	Interconnector -Bulgaria-Romania	Turkey, Serbia, Greece, Central Europe	Developing at moderate level
			Interconnector -Bulgaria-Greece		Spot Electricity Market
			South Stream		
		A new LNG terminal is planned	Bourges-Albania pipeline		
Greece	Russia and Azerbaijan Algeria, Nigeria, Qatar and other LNG sources	Interconnector Turkey-Greece-Italy (ITGI)	TAP	Southern and Central Europe	Developing at moderate level
		One LNG Terminal	The Interconnector -Bulgaria-Greece		Spot Electricity Market

(continued)

Table 8.3 (continued)

Countries	Sources (Existing and projected)	Existing projects and connection points	Potential projects and connection points	Customers	Trading environment
Italy	Algeria, Libya, Russia, Azerbaijan Algeria, Nigeria, Qatar and other LNG sources,	Trans-Mediterranean Pipeline	South Stream natural gas pipeline	Central and West Europe	Developed electricity and gas markets and derivative instruments
		Green Stream Pipeline	TAP		
		Central Europe Pipeline	Galsi		
		Two LNG Terminals			

Source: http://www.tanap.com, www.trans-adriatic-pipeline.com, http://www.south-stream.info/en/pipeline/, www.nabucco-pipeline.com, www.edison.it/en/company/gas-infrastructures/itgi.shtml (European Commission 2012)

international developments, the target model for Turkey remains unclear but, two alternatives have been proposed: "Transit" and "re-export." The former depends on the energy bridge role and requires the maximum utilization of gas transit across Turkey to the EU to raise transit service revenues. On the other hand, the re-export model may be possible if Turkey is able to import gas from countries in the region into the Turkish gas pool – either under purchase contracts allowing re-export or through active involvement in upstream production areas – and then concluding sales agreements for re-exporting to the EU (Deloitte 2012). Undoubtedly, the second model is more advantageous, and would make Turkey a strong regional power. However, no neighbor country except Azerbaijan is preparing the way for this. Furthermore, the TANAP project alone guarantees a fight for Turkey to re-export gas to third countries.[10] Turkey is still seeking a re-export clause in its contract to import Russian natural gas and looking for new opportunities to re-export Iranian and Iraqi gas in this complex political arena. The current realities of the region indicate that the transit hub model, which involves a limited degree of re-export activities, is initially the more practical model. Depending on developments in international relations in coming years, Turkey may come to attach greater importance to re-export operations. Therefore, becoming a transit hub in a flexible structure, which conforms to EU standards, may be the best option for the long-run economic and political interests of Turkey.

The Deloitte report suggests that the hub can be planned according to important considerations such as the capacity to provide bi-directional gas flows under special circumstances, such as emergencies, and also that the capacity of the transit hub should exceed 100 bcm in the long-run. The report underlines that gas flow at such

[10] There is no clear statement in the intergovernmental agreement about the re-export right of Turkey. However, there is much speculation in the media (Punsmann 2012).

Table 8.4 SWOT analysis of the Turkish natural gas market

Strengths	**Weakness**
Growing Economy and gas market	Limited gas production
Supplier diversity and many points of entry	Absence of excess gas supply
Tax advantages	Undeveloped natural gas balancing system
Main input of electricity	Insufficient number of qualified personnel
Free market experience on electricity	Political invention
Eligible consumers	Insufficient storage capacity
Developing a competitive wholesale market	Weak infrastructure
Existence of an organized derivatives market	Centralized public management
Developed financial system	LNG liquefaction plant is needed
Opportunities	**Threads**
Provide positive impact on regional security	Resistance to change
Integration with electricity market	Government intervention to gas prices
Physical trading (spot and OTC)	Current legal status
Derivatives market	Insufficient transit and export regulations
Development of Eastern Mediterranean gas market	Non-transparent rules
Expected high churn rate	PKK terrorism
Shale gas reserves	Political ambition of Turkey

an important-scale can only be realistic through large-scale infrastructure investments involving international-scale companies and the organization of the hub according to EU standards to create an incentive for international investors. The report also advises the establishment of new LNG facilities in addition to existing ones, and larger storage capacity.

To realize such a flexible model, Turkey must develop not only the infrastructure of the gas market, but also the structure of the local gas market to suit the third package of the EU. This should include a new transit regime. Considering these factors, a SWOT[11] analysis of the Turkish gas market is given in Table 8.4. The major assets of the Turkish Gas market are the increasingly competitive structure of the Turkish economy, experience with electricity markets, and developments in the natural gas wholesale market. Although the state company, Botaş retains control of more than 85 % of wholesale gas trade, this proportion is likely to decline considerably in coming years. Currently, Turkey has a 'day ahead' market for electricity, and in 2011 the Turkish Derivative Exchange (Turkdex, VOB) began to develop Turkish electricity futures contracts. In addition, the Turkish government is seeking to transform Istanbul into an international financial center. The new central exchange in Istanbul will be a unique trading platform for all financial assets and commodities, except for spot electricity and gas markets, which are planned to operate in Ankara. According to this vision, electricity and natural gas derivatives will be major instruments of the Istanbul Bourse. The major weakness of the

[11] SWOT analysis is developed using the notes of various brain storming meetings of national gas associations.

Turkish gas market is the absence of both excess capacity and healthy price formation structures. Currently, gas imports are only able to meet domestic needs. It is expected that the new gas market may provide efficiency in national gas consumption. However, the rapid growth in gas consumption causes difficulties in developing a good working gas market with limited excess capacity.

The major weaknesses in the Turkish energy market are an undeveloped natural gas balancing system, lack of human capital, weak infrastructure and overly centralized public administration. The capacity of the existing domestic pipeline system must be developed to respond to domestic needs as well as international gas transit to the EU from Azerbaijan and other countries. In addition, the reservoir and daily withdrawal capacities of the gas storage facilities should be increased to prevent the seasonal imbalances in supply–demand equilibrium and to decrease the negative effects of possible interruptions in gas supply. Lastly, Turkey needs LNG liquefaction plants to become a major force in the market.

The main benefit of Turkey's role as a hub is the potential it has to trigger a boom in a regional gas distribution system and to have a positive impact on maintaining regional security and boosting cooperation. Ali (2010) underlines the importance of the role of pipelines in promoting regional peace and suggests the encouragement of energy cooperation, particularly when longstanding political disputes remain unresolved. In this respect shale gas reserves present another opportunity for Turkey.

Although a new Turkish gas market can produce valuable opportunities by integrating with the electricity and financial markets, there are a number of threats, including resistance to change, legal status, political interventions and non-transparent rules of the Turkish bureaucracy. Other hindrances, which have been highlighted, are the dangers of PKK terrorism (Eissler 2012) and the political ambition of Turkey as a rising regional power. Pacheco (2011) pointed out the challenges that Turkey faces in reaching its goal of becoming a regional power, and of asserting its influence in the neighboring regions by means of the energy tool.

In addition to political issues, the latest developments in global gas pricing after the 2008 financial crisis will affect gas market reform (Stern and Rogers 2011). It seems that the discussion on the commonly used oil indexation system and newly developing market-based pricing will not only influence energy markets in Europe, but also markets in Asia and non-market-based pricing systems (Melling 2010). The market-based price system is supported by factors including the increased supply of LNG worldwide, unconventional gas production in North America, a rapidly increasing LNG receiving terminal capacity in northwestern Europe; the recession in most countries of the world; and the advancement in the gas market of the EU supporting the market-based pricing system (Frisch 2010).

Finally, we must emphasize that the support of the EU and the U.S. is vital for the success of Turkey's pipeline projects. Recently, the EU and the U.S. repeated their support for Turkey's further development as an energy bridge and potential energy hub, which will benefit all three parties (EC, June 14, 2012 and Gulustan info, Nov 21, 2012).

Conclusion

The southwest energy corridor of Europe has not only become increasingly important for the energy security of the EU and Turkey, but also for regional cooperation and peace in the Middle East and Asian countries. The role of Turkey as a natural energy bridge with other assets is critical for the region (Winrow 2009; Pacheco 2011). Since the late 1990s, when the vision of becoming a natural gas hub emerged, Turkey has made considerable progress in reforming the energy sector following the energy policy of the EU, and also has improved the local infrastructure, constructed new pipelines to connect with her neighbors, and developed new projects. Although Turkey has a natural advantage in this role, the conditions for becoming a transit hub have not been fulfilled. Turkey has not yet been able to organize a structural relationship for a value-chain from well-head to the markets. The future of a southwest natural gas hub depends not only on local factors, but also on international developments. Despite comparative advantages, Turkey still faces competition from Bulgaria, Greece and Italy as potential energy transit hubs, and international developments will affect this competition.

The Turkish gas market is still developing and the role of the state is very strong, particularly in the wholesale gas trade. The main state company, Botaş, continues to control the market and the government controls pricing in the retail market. Since the natural gas spot market has not yet been established, consumption of natural gas has not reached its full potential. In addition to inadequacies in infrastructure, storage capacity and LNG terminals, Turkey has a limited number of qualified personnel in the energy sector. Roberts (2010) reminds the Turkish government that "the future of Turkey as a gas trading hub lies very much in Turkey's own hands. For such a hub to emerge will require Turkey to opt for domestic market liberalization over statism". The centralized structure of Turkish bureaucracy, political interventions, non-transparent operations and corruption, which are all rooted in excessive statism, may create barriers to the creation of a Turkish hub, which is undoubtedly the greatest project of the Turkish Republic.

Developments in international energy projects, political relations and worldwide energy politics will play significant roles in shaping the future of energy hubs in the region. Particularly, potential for a nuclear conflict with Iran, the Arab Spring and relations between Central Asian countries and Russia are taking priority over economic initiatives. The most important asset of Turkey is the TANAP project, which may enable Turkey to re-export gas from Azerbaijan and some other central Asian countries to international markets. It is very difficult to predict developments in the Middle East as the region is being reshaped by international politics. The outlook may become clearer in the next few years, at which point it may be possible to determine whether Turkey will be an access point to Northern Iraqi gas, and perhaps whether other opportunities to export gas will transpire in the wake of the Arab Spring. During this golden age of gas, the bargaining position with Russia may influence Turkey's situation positively.

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Part III

Market Risks

Hedging and Speculation: A Discussion on the Economic Role of Commodity Futures Markets (Including the Oil Markets)

9

Hilary Till

Abstract
In the United States, there is a rich historical experience with controversies over futures trading that date back to the nineteenth century. After a brief recounting of history, this chapter notes that a review of U.S. history provides valuable lessons in figuring out what is necessary for commodity futures trading (including oil trading) to continue and prosper during times of political pressure. Essentially, one finds that the following actions have been indispensable in responding to past controversies over futures trading: (1) an increase in transparency in showing how these markets actually work; and (2) an improvement in public education on the economic usefulness of commodity markets. This chapter endeavors to help in providing precisely that education.

9.1 Introduction

This chapter argues that commodity futures markets and its participants have an essential economic role. As such, the task of this chapter is to explain why this is the case. Specifically, given the re-emergence of controversies over commodities trading, including in the oil markets, this chapter will provide a basic primer on the following topics:

1. The role of futures prices in revealing fundamental information on commodity markets, especially in the crude oil markets;
2. The short-term interaction effect between traders and price;
3. The economic role of hedgers and speculators in the commodity futures markets;
4. Expected commodity price behavior during times of scarcity; and
5. The empirical evidence on the role of the speculator.

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The chapter also includes an explanation of how the terms, “hedging” and “speculation,” are not precise. What futures markets accomplish is the specialization of risk-taking rather than the elimination of risk.

In addition, this chapter discusses how there is some empirical evidence to support the theory that speculative involvement *actually* reduces price volatility. The paper explains that even when commodity futures markets are viewed as “hedging” markets, there is still a vital role for speculators because there will not always be an even balance of short hedgers and long hedgers at any one time. Speculators are needed to balance the market.

In covering commodity price spikes, including in the oil markets, the chapter discusses the difficulty of understanding intuitively how to apportion causality when dealing with a non-linear function. There were a myriad of incidental factors in 2008 that, in combination, led to the oil price spike of 2008, once spare capacity in light sweet crude oil became so stretched.

The chapter also covers the challenges that have resulted from all risky assets, including individual commodity markets, becoming synchronized since the onset of the Global Financial Crisis of 2008. In addition to covering these topics, this chapter briefly analyzes regulatory proposals that resulted from the current controversies over commodities trading, including in the oil markets.

The chapter concludes with noting how commodity futures markets have been the successful product of 160 years of trial-and-error efforts. The results of these efforts have been an effective price discovery process and meaningful risk management benefits for commercial participants. After reviewing these benefits, a reader may come to understand why a large body of academics and practitioners desire to protect these vital institutions.

9.2 Historical Controversies Over Futures Trading

One could argue that our current era bears a number of similarities to the last great era of globalization in the late nineteenth century. The period from 1880 to 1914 “first harnessed the powers of global communications and swift transport to link the world economically,” noted Sesit (2005). “Other parallels . . . include deregulated and integrated global capital markets, expanding international trade, strong foreign-direct investment flows and the search for new markets,” continued Sesit (2005) in citing George Magnus of UBS.

US Congressional testimony from 1892 shows how extremely unpopular futures trading had been, given the competitive dislocations that were occurring at the time. A review of the politics around futures trading since the 1890s does give one a sense of déjà vu in examining the current controversies over commodity futures trading.

Sanders et al. (2008) discuss a more recent period that also has similarities to the present, the mid-1970s: “U.S. and international commodity markets experienced a period of rapid increases from 1972 to 1975, setting new all-time highs across a broad range of markets.” These price increases were blamed on speculative behavior associated with the "tremendous expansion of trading in futures in a wide range of commodities," according to Cooper and Lawrence (1975).

Not surprisingly, "public pressure to curb speculation resulted in a number of regulatory proposals," wrote Sanders et al. (2008) while "in hindsight, economists generally consider this a period marked by rapid structural shifts such as oil embargoes, Russian grain imports, and the collapse of the Bretton Woods fixed exchange-rate system," according to Cooper and Lawrence (1975).

After this brief recounting of history, it may not be surprising that a review of U.S. history also provides valuable lessons in figuring out what is necessary for commodity futures trading to continue and prosper during times of political pressure. Essentially, one finds that the following actions have been indispensable in responding to past controversies over futures trading:

1. Public education on the economic usefulness of commodity markets, and
2. Increased transparency in showing how these markets actually work.

The next sections of this chapter will endeavor to demonstrate these two points.

9.3 The Role of Price in Revealing Fundamental Information

In popular narratives on the oil markets, one is frequently confronted with the question: do the fundamentals justify the price?

For an oil-futures trader, even the premise of this question is perplexing. Instead, a veteran oil-futures trader always asks the opposite question: what is the price telling me about fundamentals? The reason for this difference in outlook is simple: the market imposes a sufficient discipline to prevent a trader from ignoring price for anything but a very short space of time. We do not expect that commodity futures traders will ever have the benefit of a term-lending facility, or become the beneficiaries of other large-scale government bail-outs for unwise (or unlucky) financial participants. Commodity futures traders are instead forced to rely on disciplined risk management, which ultimately is based on an in-depth understanding of price and its statistical characteristics.

A futures trader also interprets a commodity's price as part of a dynamic process. A commodity's price moves in whatever direction is needed in order to elicit a supply or demand response that will balance a commodity market. It may be useful to review the technical aspects of this interplay.

For a number of commodities, either storage is impossible, prohibitively expensive, or producers decide it is much cheaper to leave the commodity in the ground than store above ground. The existence of plentiful, cheap storage can act as a dampener on price volatility since it provides an additional lever with which to balance supply and demand. If there is too much of a commodity relative to demand, it can be stored. In that case, one does not need to rely solely on the adjustment of price to encourage the placement of the commodity. If too little of a commodity is produced, one can draw on storage; price does not need to ration demand.

Now, for commodities with difficult storage situations, *price has to do a lot (or all) of the work of equilibrating supply and demand, leading to very volatile spot commodity prices*. A defining feature of a number of commodities is the long lead-

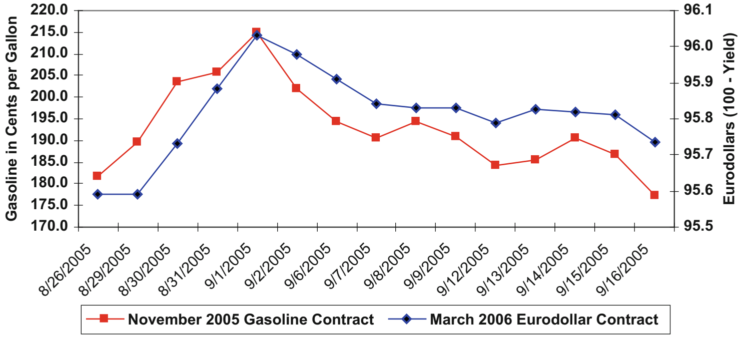

Fig. 9.1 Gasoline and short-term U.S. interest rates around the time of Hurricane Katrina End-August through Mid-September 2005

time between deciding on a production decision and the actual production of the commodity. It is impossible to exactly foresee what demand will be by the time a commodity is produced. This is why supply and demand will frequently not be in balance, leading to large price volatility for some commodities.

In the case of oil, it is prohibitively expensive to store more than several months worth of global consumption. Rowland (1997) explained the situation as follows:

> From wellheads around the globe to burner tips, the world's oil stocks tie up enormous amounts of oil and capital. The volume of oil has been estimated at some 7-to 8-billion barrels of inventory, which is the equivalent of over 100 days of global oil output or 2 ½ years of production from Saudi Arabia, the world's largest producer and exporter of crude oil. Even at today's low interest rates, annual financial carrying costs tied up in holding these stocks amount to . . . more than the entire net income of the Royal Dutch/Shell Group. (p. 7)

One can look at the aftermath of Hurricane Katrina in the United States in 2005 for a good concrete example of the dynamic interplay between an oil product's price and its supply-and-demand situation. With the onset of Hurricane Katrina, the price of gasoline (petrol) rallied 18 % in 4 days before falling back about the same amount 15 days later, which is illustrated in Fig. 9.1.

Were the markets irrational in rallying so much in 4 days, given how short-lived these price increases were?

According to a *Dow Jones Newswire* report (2005), "[Hurricane] Katrina shut in nearly all of oil and gas production in the Gulf of Mexico . . . The large scale supply disruption and fear of an economic shock triggered a massive government response. The outages prompted the Bush administration to release Strategic Petroleum Reserve oil, waive air-pollution rules on fuels, and ease restrictions on use of foreign-flagged vessels to carry fuel in U.S. waters." Further, "[m]embers of the Organization of Economic Cooperation and Development agreed . . . to [release] 2 million barrels a day of crude oil and petroleum products from their strategic stocks for 30 days."

One could argue that this unprecedented government response caused gasoline prices to decline from their post-Katrina peak. Further, and as also illustrated in

Fig. 9.1, with that response, fears of an economic slump diminished, which in turn caused deferred interest-rate contracts to also decline, as the market resumed pricing in the expectation that the Federal Reserve Board could continue tightening interest rates at the time.

With this brief example, we see how the dynamic change in the price of gasoline induced an international and domestic response to increase supplies; and that once achieved, the price responded by quickly decreasing. Quite simply: price did its job.

9.4 The Technicals: The Interaction Effect Between Traders and Price

To be fair to those who see speculators as the cause of major commodity price moves, including in the oil markets, one can say that there has been evidence in the past across a number of commodity markets for an interaction effect between traders and price. This is analyzed, for example, in Hoffman and Duvel (1941) for grain trading on the Chicago Board of Trade; in Gilbert (2007) for metals trading on the London Metals Exchange (LME); and in Verleger (2007) for oil trading on the New York Mercantile Exchange (NYMEX).

The Hoffman and Duvel (1941) study finds that neatly ascribing price to either market fundamentals or trading activity is unsatisfactory. The authors of this study allow that "grain prices [may] reflect not only the forces originating in the production and merchandising of grain, but also those generated in the process of market trading. This school [of thought] holds that while a long-run average of prices will conform fairly closely to fundamental trade facts, *there is no assurance at any given time that this will be the case due to the uncertain nature of purely market operations*." (p. 9) [Italics added.]

9.4.1 Dynamic Hedging and Negative Gamma

Verleger (2007) explained how the activity of traders may have (temporarily) interacted with market fundamentals to magnify the oil-price rally during the Fall of 2007. Verleger noted how large-scale industrial consumers, such as airlines, had purchased out-of-the-money call options on oil futures contracts in order to protect against price rises. Obviously, someone had to sell the industrial consumers these options: the money-center banks. As crude oil rose towards the level(s) where there was a concentration of call-option-strikes, this might have created a cascade of dynamic-hedging purchases by bank dealers, who in turn were hedging the options they had written. This might have caused the oil price to (temporarily) rise still further.

In the terminology of derivatives traders, the bank dealers likely had maximum "negative gamma": their exposure to being short crude was rising at an accelerating rate, forcing them to purchase crude oil contracts at an accelerating rate, too. Once market participants became aware of this interaction effect, it had been common in 2008 to note where the concentrations of option strikes were in the crude-oil futures market. Futures traders do not have access to data in the over-the-counter (OTC) market, where the large-scale transactions are taking place, but one expects some of this activity to show up in NYMEX option open interest, as bank dealers likely hedge some of their OTC derivatives exposure in the exchange-traded market. Therefore, one of the tools in the arsenal of a short-horizon oil futures trader has become to examine where the concentrations of option strikes are on the NYMEX.

Why would market participants monitor where there is a concentration of open interest in particular option strikes in a commodity market? If the spot price of a commodity approaches such a strike price, there could be a cascade of dynamic hedging orders by options dealers, which would temporarily cause the commodity price to overshoot by more than it otherwise would.

Verleger (2007) provided another historical example. During August-2006-through-January-2007, oil put purchases by producers may have (temporarily) caused oil futures prices to temporarily overshoot to the downside as well.

As the above examples should make clear, futures traders are aware that market-microstructure effects may predominate as the driver of price over *short* timeframes.

9.4.2 Liquidation Pressure

Futures traders are also aware that the effects of traders having to liquidate large positions can also be a temporary, but meaningful, driver of price. Because there are vigorously enforced laws in the United States regarding actual or attempted manipulation of *physical* energy markets, the accumulation of extremely large derivatives positions in the U.S. energy markets, which in turn do not have a well-defined commercial purpose, is a very risky activity since a trader will not be able to resolve the position in the physical markets, without triggering regulatory scrutiny. Till (2008b) describes a U.S. Commodity Futures Trading Commission (CFTC) and U.S. Department of Justice action against a major international oil company where the company was fined $303-million for attempting to manipulate one U.S. delivery location's physical propane market. The firm's positions were initially entered into through the forward OTC markets. This case was particularly striking since the firm had *actually failed* in this attempted manipulation and had lost at least $10-million in attempting to carry out this "market corner."

Therefore, a large holder of energy derivatives contracts will generally not resolve their position in the physical markets, if there is no legitimate commercial reason to do so. If that holder then needs to liquidate a position, then that participant needs to have another participant take on his (or her) position.

As discussed in Till (2006), the commodity markets, including oil, frequently do not have natural two-sided flow. For experienced traders in the fixed income, equity, and currency markets, this point may not be obvious. If a commercial market participant needs to initiate or lift hedges, there will be flow, but such transactions do not occur on demand. Before a trader initiates a position, particularly one that is large compared to the size of the market-place, one needs a clear understanding of what flow or catalyst will allow the trader out of a position.

When large holders of energy-derivatives positions have not had an appropriate exit strategy, the outcome has consistently been an unhappy one for speculators, hedge funds, and their investors with the case of Amaranth in 2006 being only one example. The market tends to extract a large premium from a trader during a distressed liquidation with a consequent (but temporary) impact on price. In De Souza and Smirnov (2004), the authors modeled the price process during a distressed liquidation as being a kind of barrier-put option. Once a fund crosses a threshold of losses, a cycle of investor redemptions occur and/or the fund's prime brokers demand the reduction of leverage, and the fund's net asset value thereby declines precipitously as the fund sells off holdings in a distressed fashion. This "critical liquidation cycle" obviously has a (temporary) effect on the price of the fund's holdings, illustrating another interaction effect between traders and price.

De Souza and Smirnov were not specifically addressing liquidations in the commodity markets, but their work definitely has applicability to the energy markets, again as the case of Amaranth demonstrated, and as discussed in Till (2006, 2008a).

9.5 The Economic Role of Hedgers and Speculators in the Commodity Futures Markets

We will now turn our attention to explaining the economic role of hedgers and speculators in the commodity futures markets based on reviewing both the historical and empirically-grounded literature. Classically under the "longstanding hedging pressure theory . . . commercial hedgers . . . are typically net short in the commodity futures markets," as explained by Cheng et al. (2012). That said, obviously a hedger can be a consumer of commodities as well.

One nuanced point to make is that the terms, "hedging" and "speculation," are not precise, as developed by Cootner (1967) and discussed in Till (2012a, b). For example, a commodity merchant who hedges inventories creates a "basis" position and is then subject to the volatility of the relationship between the spot price and the futures price of the commodity. The merchant is, in effect, speculating on the "basis." The basis relationship tends to be more stable and predictable than the outright price of the commodity, which means that the merchant can confidently hold more commodity inventories than otherwise would be the case. What futures markets make possible is the specialization of risk-taking rather than the elimination of risk.

Who would take the other side of the commercial hedger's position? Answer: A speculator who specializes in that risk bearing. The speculator may be an expert in the term structure of a futures curve and would spread the position taken on from the commercial hedger against a futures contract in another maturity of the futures curve. Or the speculator may spread the position against a related commodity. Till and Eagleeye (2004, 2006) provide examples of both intra-market spreading and inter-market spreading, which arise from such risk-bearing.

Alternatively, the speculator may detect trends resulting from the impact of a commercial's hedging activity, and be able to manage taking on an outright position from a commercial because the speculator has created a large portfolio of unrelated trades. Presumably, the speculator will be able to dampen the risk of an outright commodity position because of the diversification provided by other unrelated trades in the speculator's portfolio. In this example, the speculator's risk-bearing specialization comes from the astute application of portfolio theory.

What then is the economic role of commodity speculation and its "value to society"? Ultimately, successful commodity speculation results from becoming an expert in risk bearing. This profession enables commercial entities to privately finance and hold more commodity inventories than otherwise would be the case because they can lay off the dangerously volatile commodity price risk to price-risk specialists. Those commercial entities can then focus on their area of specialty: the physical creation, handling, transformation, and transportation of the physical commodity.

Cootner (1961) wrote that in the absence of being able to hedge inventories, a commercial participant would not rationally hold "large inventories ... unless the expected price increase is greater than that which would be required to cover cash storage costs by an amount large enough to offset the additional risk involved."

If the existence of price-risk-bearing specialists ultimately enables more inventories to be created and held than otherwise would be the case, we would expect their existence to lead to the lessening of price volatility. To be clear, why would this be the case?

The more speculators there are, the more opportunity there is for commercial hedgers to find a natural other side for hedging prohibitively expensive inventories. This in turn means that more inventories can be economically held. Then with more inventories, if there is unexpected demand, one can draw from inventories to meet demand, rather than have prices spike higher to ration demand.

9.5.1 Reduction of Volatility

There is some empirical evidence to support the theory that speculative involvement *actually* reduces price volatility.

For example, Professor David Jacks examined what happened to commodity-price volatility, across countries and commodities, before and after specific commodity-contract trading has been prohibited in the past. Jacks (2007) also examined commodity-price volatility before and after the establishment of futures markets, across time and across countries. Jacks' study included data from 1854 through 1990. He generally, but not always, found that commodity-price volatility was greater when there were *not* futures markets than when they existed, over 1-year, 3-year, and 5-year timeframes.

More recently, Irwin and Sanders (2011) note that "[commodity] index positions [have] led to lower volatility in a statistical sense," when examining 12 agriculture markets and 2 energy futures markets from June 2006 to December 2009.

Specifically, "... there is *mild* evidence of a negative relationship between index fund positions and the volatility of commodity futures prices, consistent with the traditional view that speculators reduce risk in the futures markets and therefore lower the cost of hedging." (p. 24) [Italics added.]

9.5.2 Holbrook Working's Speculative T-Index

The historical writings of Holbrook Working frequently provide insight and a sense of constancy in how to frame the ongoing (tumultuous) debate on futures trading. Working was a Stanford University professor whose writings on the economic role of futures trading are considered fundamental to our present understanding of these markets. His work spanned the 1920s through the 1970s.

According to Working, the economic purpose served by commodity futures markets is to allow commercial participants to hedge prohibitively expensive inventories. The role of the speculator, then, is to take on and manage this risk. If one accepts this framework, then one does not see futures exchanges as casinos.

A U.S. federal agency (which preceded the CFTC) provided data that classified market participation as either hedging or speculation. With this data, one could construct ratios to see how much excess speculation (if any) there was over hedging needs. Holbrook Working created a simple ratio to do just that. This is Working's Speculative T index.

Sanders et al. (2008) define the Working T index as follows:

"$T = 1 + SS \;/\; (HL + HS) \;\text{ if }\; (HS >= HL)$
or
$T = 1 + SL \;/\; (HL + HS) \;\text{ if }\; (HL > HS)$

where open interest held by speculators (non-commercials) and hedgers (commercials) is denoted as follows:
SS = Speculation, Short
HL = Hedging, Long
SL = Speculation, Long
HS = Hedging, Short"

Some explanation is in order to make this statistic (hopefully) intuitive. The denominator is the total amount of futures open interest due to hedging activity. If the amount of short hedging is greater than the amount of long hedging, then speculative longs are needed to balance the market; and technically, speculative shorts are not required by hedgers. Any surplus of speculative short positions would thereby need to be balanced by additional speculative long positions. Technically, then the speculative short positions would appear to be superfluous or perhaps even "excessive." The Speculative T index measures the excess of speculative positions beyond what is technically needed to balance commercial needs, and this excess is measured relative to commercial open interest.

Sanders et al. (2008) explain, "Working is careful to point out that what may be 'technically an *excess* of speculation is economically necessary' for a well-functioning market."

For the Speculative T index, are value(s) greater than 1 considered excessive?

The following are average T indices from historical agricultural studies, excerpted from Sanders et al. (2008):

1.21 (calculated from 1954–1958 data);
1.22 (calculated from 1950–1965 data);
1.26–1.68 (calculated from 1947–1971 data); and
1.155–1.411 (calculated from 1972–1977 data).

Evidently, the concern in past historical studies was the *inadequacy* of speculation in the agricultural futures markets, so these historical T indices would therefore *not* be considered indicative of excessive speculation.

Interestingly, the past historical studies referenced in Sanders et al. (2008) contradict the assertion that well-functioning commodity futures markets should necessarily relegate speculative participation to a residual role. Perhaps if one sees commodity speculators as a heterogeneous set of risk-bearing specialists, then one would understand why it would not be beneficial to force speculative participation into a tertiary role.

Sanders et al. (2008) studied whether there was excessive speculation in the agricultural futures markets, updating previous studies that began with Working (1960), and using Working's T index. After calculating Working's T index across agricultural futures markets, these economists found no pervasive evidence that recent speculative levels were in excess of those recorded historically for agricultural futures markets, even after accounting for index trader positions.

In the Fall of 2009, the CFTC released a new dataset, which facilitates further analysis of the speculative excess hypothesis across commodity markets. Specifically, on October 20th, 2009, the CFTC released 3 years of enhanced market-participant data for 22 commodity futures markets in a new "Disaggregated Commitments of Traders" (DCOT) report. The release of this data was important because one could then evaluate whether the balance of outright position-taking in the U.S. exchange-traded *crude oil* derivatives markets had been excessive relative to hedging demand during the previous 3 years. One could do so by calculating T indices for the U.S. crude oil market.

Using this data and with some notable caveats, one could conclude that speculative position-taking in the U.S. oil futures markets did not appear excessive when compared to the scale of commercial hedging at the time, according to Till (2009). One has to be careful with how strongly one states this paper's conclusions since, for example, the paper did not examine whether there was excessive speculation in the oil markets in other venues besides the U.S. oil futures markets.

9.6 Commodity Price Behavior During Times of Scarcity

Professor Christopher Gilbert has explained why temporarily large price rises in commodity markets can occur [in Gilbert (2007)]:

> Commodity markets are characterized by very low short-run elasticities of both production and consumption, although long-run supply elasticities are probably high. . . . [I]n a tight market in which only minimum stocks are held, the long-run price becomes irrelevant. With inelastic short-run supply and demand curves, the market clearing price ceases to be well-defined, not in the sense that the market does not clear, but in the sense that it will be very difficult to assess in advance at what price, market clearing will result. Fundamentals-based analysis may show where the price will finish but this will provide very little guide as to where it will go in the meantime. (p. 23)

Gilbert (2007) further explains that "when markets become tight, inelastic supply and demand make prices somewhat arbitrary, at least in the short term. There will always be a market clearing price but its level may depend on incidental . . . features of the market."

Arguably, one can apply Gilbert's description to crude oil in the recent past.

Effective spare capacity[1] in OPEC was only 1.5-million barrels per day in July 2008, according to IEA (2008b). One-and-a-half-million-barrels-per-day was an exceptionally small safety cushion, given how finely balanced global oil supply-and-demand was. Given the risk of supply disruptions due to naturally-occurring weather events as well as due to well-telegraphed-and-perhaps-well-rehearsed geopolitical confrontations, one would have preferred at the time for this spare-capacity cushion to have been *much* higher.

In Till (2008c), we discussed what may have caused the oil price rally that culminated in the July 2008 price spike. There were a number of plausible fundamental explanations that arose from any number of *incidental* factors that came into play when supply-and-demand was balanced *so* tightly, as was the case with light sweet crude oil. In 2008, these *incidental* factors included a temporary spike in diesel imports by China in advance of the successful Beijing Olympics, purchases of light sweet crude by the U.S. Department of Energy for the Strategic Petroleum Reserve, instability in Nigeria, and tightening environmental requirements in Europe. One should add that this is not an exhaustive list. The natural conclusion to observing that many seemingly inconsequential factors, in combination, could lead to such a large rise in the price of crude oil during the first 7 months of 2008, is that the market was signaling a pressing need for an increase in spare capacity in light-sweet crude oil, however achieved.

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[1] "Spare capacity refers to production capacity less actual production; it quantifies the possible increase in supply in the short-term," explains Khan (2008).

9.7 Empirical Evidence on the Role of Both Speculators and Financial Investors

9.7.1 Speculative Positions Have *Followed* Price Changes

In May 2010, the *Wall Street Journal* obtained unreleased CFTC reports through a Freedom of Information Act request, as reported by Lynch (2010). According to ITF (2009), which can be accessed at the *Wall Street Journal*'s website, CFTC staff had found that for crude oil prices from January 2003 to October 2008, price changes *led* position changes, rather than the other way around. If speculators were indeed driving price changes over this period, one would have expected their position changes, instead, to have *led* price changes. This particular time period was noteworthy since it encompassed the July 2008 crude oil price spike.

9.7.2 Evidence on the Impact of Commodity Index Funds

Did commodity index investments in 2008 cause the 7-month oil-price rally that culminated in July of 2008? According to data released by the CFTC on September 11th, 2008, this is an unlikely cause, given that total OTC and on-exchange commodity index investment activity in oil-futures-contract-equivalents actually *declined* from December 31st, 2007 through June 30th, 2008. Please see Fig. 9.2.

9.7.3 There Is Indeed an Increase in the Co-movements Between Commodity Prices and Financial Asset Prices, but What Is the Implication for "Social Welfare"?

This is the question posed by Fattouh et al. (2012). These researchers note that in the case of oil:

> [G]reater financial market integration may reduce the market price of risk and increase the level of inventories by reducing the cost of hedging. While this mechanism induces an increase in the spot price, the higher level of inventories reduces the chances of future price hikes. (p. 8.)

Fattouh et al. (2012) continue:

> [E]vidence of increased comovement between the spot price of oil, oil futures, and other asset prices does not imply that the [past] surge in the spot price was caused by financial speculators. . . . To the extent that global macroeconomic fundamentals have changed in recent years, . . . that fact could provide an alternative explanation for the observed comovement . . . (p. 8.)

Commodity markets have become more highly correlated to U.S. equities since 2008. This was noted, for example, by Kawamoto et al. (2011):

Total OTC and On-Exchange Commodity Index Investment Activity

	12/31/07	**3/31/08**	**6/30/08**
Crude Oil Index Values Measured in Futures [Contract] Equivalents	**408,000**	**398,000**	**363,000**

Fig. 9.2 Excerpt from staff report on commodity swap dealers & index traders with commission recommendations (Source: CFTC 2008)

> With regard to the cross-market linkage between commodity and stock markets, the correlation coefficient of the return between the markets has risen rapidly since the second half of 2008. (p. 4)

Figure 9.3 graphically illustrates this particular increased correlation.

Market practitioners are well aware of the increase in correlations across *all* asset classes, including commodities, since the onset of the Global Financial Crisis. In April 2012, Williams et al. (2012) explained that:

> In a world where disparate assets move in lockstep, their individual identities become lost. Assets now behave as either risky assets or safe havens . . . Synchronised markets provide little diversification . . . (p. 1)

Williams et al. (2012) refer to this new market behavior as "Risk On – Risk Off (RORO)." RORO may be a "consequence of a new systemic risk factor":

> We have seen global intervention, QE [Quantitative Easing] and policy response of an unprecedented scale across many countries – and markets are pricing in the bimodal nature of their consequences. Ultimately, either policy response works and there is indeed a global recovery, or they fail and the sovereign debt issues across the developed world lead to new and even more serious [financial] crises. Individual assets [including commodities], while still influenced by their fundamentals, are dominated by the changing likelihood of such a recovery. Disparate markets now have an ascendant common price component and correlations surge whenever an unsettling event increases the degree of uncertainty. (p. 4)

Cheng et al. (2012) provide convincing evidence of one aspect of the "RORO" environment, which began after the 2008 Lehman crisis. ". . . [W]hile financial traders accommodate the needs of commercial hedgers in normal times, in times of financial distress, financial traders reduce their net long positions [in commodities] in response to an increase in the VIX[,] causing the risk to flow to commercial hedgers."

The researchers state that:

> Our analysis shows that while the positions of CITs [Commodity Index Traders] and hedge funds complement the hedging needs of commercial hedgers in normal times, their own financial distress rendered them liquidity consumers rather than providers during the financial crisis. (p. 6)

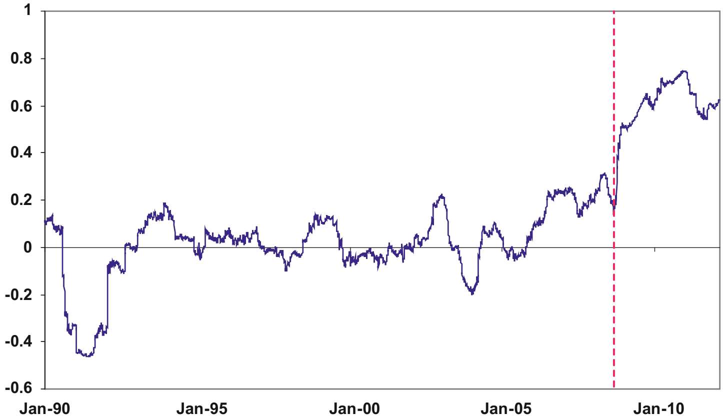

Fig. 9.3 Return correlation coefficient between commodity index and equity index daily return (1/2/90 to 2/17/12) (Source: Based on Kawamoto et al. (2011), Chart 2. The figure shows the 1-year rolling correlation coefficients between the return of the global equity index [MSCI AC World Index] and that of the commodity index [S&P GSCI]. Note: The vertical line demarks the second half of 2008. [Bloomberg tickers: MSCI AC World USD: MSEUACWF Index; and S&P GSCI Excess Return: SPGCCIP Index.])

Cheng et al. (2012) also show how sensitive the returns of *all* individual commodities have become to changes in the VIX.

The G20 Study Group on Commodities (2011) acknowledged this new state-of-the-world:

> The expansion of market participants in commodity markets increases market liquidity (including in longer term contracts), thereby accommodating the hedging needs of producers and consumers. . . . On the other hand . . . (the) increased correlation of commodity derivatives markets and other financial markets suggests a *higher risk of spillovers*. (p. 43) [Italics added.]

In debating the significance of the "higher risk of spillovers," one could also note, as the Deputy Governor of the Bank of Canada did, that "similar, if not larger, [price] spikes were witnessed during the Great Depression and the tumultuous 1970s and 1980s," according to Hickley (2011).

What this means for commodity market participants, whether they are hedgers or speculators, is that results such as those in the Cheng et al. (2012) study will have to be considered in managing commodity risk. This is similar to the advice provided by Williams et al. (2012) in advising asset managers to rethink portfolio construction in an era of assets losing their "individual identities."

Regarding the Cheng et al. (2012) study, one should add that it is not a new phenomenon for commercial market participants to have to step in when risk-bearing-specialists become in distress. As discussed in Till (2008a), the hedge fund, Amaranth, took on price risk from physical natural gas participants, who had wanted to hedge their forward production. When the hedge fund became in distress in 2006, it is likely that these commercial hedgers were then the ultimate risk takers on the other side of Amaranth's distressed trades, and so benefited from the temporary dislocations that ensued from the fund's collapse. In other words, it does not appear that the commercial natural-gas industry was damaged by the crisis caused by Amaranth; in fact, commercial-market participants likely benefited. Natural gas commercial hedgers would have earned *substantial* profits had they elected to realize their hedging windfall during the 3 months that followed the Amaranth debacle.

That said, what is new about the current risk environment is that a price-risk-bearing specialist may not be able to assume diversification across individual commodities (and other financial instruments) when using portfolio theory to manage commodity risk. As a result, this type of risk specialist must reduce leverage in this activity. Assuming this conclusion is embraced in a widespread manner, the "higher risk of spillovers" resulting from the "financialization of commodities" may lessen.

9.8 Regulatory Proposals

9.8.1 Placeboes

The main problem with proposals on restricting speculative participation, so as to avoid future price spikes, is that this solution may actually be a placebo.

Former U.S. CFTC Commissioner Michael Dunn noted in an article by Loder and Brush (2011):

> My fear is that, at best, position limits are a cure for a disease that does not exist. Or at worst, a placebo for one that does.

Further, according to CFTC (2009), a U.S. CFTC staff economist memorandum stated at the time that:

> In our analysis of the impact of position limits, we find little evidence to suggest that changes from a position limit regime to an accountability level regime or changes in the levels of position limits impact price volatility in either energy or agricultural markets. Our results are consistent with those found in the existing literature on position limits.

Consistent with Dunn's view, IEA (2008a) warned, "Blaming speculation is an easy solution[,] which avoids taking the necessary steps to improve the supply-side access and investment or to implement measures to improve energy efficiency."

9.8.2 CFTC's Position Limit Rule

CFTC (2011) announced that commodity position limits shall be as follows. "Spot-month position limits will be set generally at 25% of estimated deliverable supply. . . . Non-spot-month position limits . . . will be set using the 10/2.5 percent formula:

10 percent of the contract's first 25,000 [contracts] of open interest and 2.5 percent thereafter."

Summarizing from Young et al. (2011), one should note the following about the CFTC's position limit rules:

(a) The CFTC did not "make a finding that its adopted position limits . . . [were] necessary."
(b) The "CFTC has not argued that position limits will be effective in lowering commodity prices."
(c) The "CFTC contends that it is imposing position limits because 'Congress did not give it a choice.'"
(d) The CFTC did "not provide empirical evidence to demonstrate that the position limits it is imposing are appropriate."
(e) A dissenting CFTC Commissioner stated that "whatever limits the Commission sets . . . [should be] supported by empirical evidence demonstrating those [limits] would diminish, eliminate, or prevent excessive speculation."
(f) The dissenting commissioner also stated that "without empirical data, we cannot assure Congress that the limits we set will not adversely affect the liquidity and price discovery functions of affected markets." (pp. 2–4)

In September 2012, a U.S. federal court overturned the CFTC's position limit rules. The court noted that in prior federal agency decisions to impose speculative position limits, dating back to 1938, the relevant agency had made "necessity findings in its rulemakings" of actual or potential harmful excessive speculation, as noted in Glans (2012).

The CFTC precisely did not do so during the current iteration of federal position limit rulemakings. And in fact, three Commissioners had noted that no such finding had been made. The court essentially found that a plausible, "plain reading" of the Dodd-Frank amendments to the Commodity Exchange Act could lead one to conclude that the CFTC still needed to make a finding of necessity before imposing new limits.

The court acknowledged that there is some ambiguity on this point; that is, there is more than one plausible interpretation of the Dodd-Frank amendments regarding whether the imposition of federal position limits is mandatory or not. That said, the court ruled that the CFTC would need to specifically address this ambiguity with its expertise rather than asserting that this ambiguity does not exist. The court's decision is nuanced. If the CFTC did at some point make a finding of the economic necessity of its federal position limit rules, rather than assert that Congress made it mandatory for these limits to be imposed, regardless of need, then one could expect that a later imposition of position limits could survive a future court challenge.

9.8.3 Transparency of Position-Taking

One can easily endorse proposals for transparency in position-taking in all financial centers. This endorsement is the result of hard-won lessons from U.S. history.

Based on Working (1970), the historical lessons from past challenges to futures trading in the United States are as follows:

(a) Constantly revisit the economic usefulness of commodity futures trading;
(b) Insist upon transparency in market-participation and position data in a sufficiently disaggregated fashion as to be useful, but also in a sufficiently aggregated fashion as to not violate individual privacy.
(c) Carry out empirical studies to confirm or challenge the benefits and/or burdens of futures trading.

9.8.4 Commodity Index Products

Regarding any proposals to ban commodity index products, one would think this would be an unfortunate precedent without solid evidence of these products being a "detriment to society."

Conclusion

Modern commodity futures markets have been the product of 160 years of trial-and-error efforts. One result has been the creation of an effective price discovery process, which in turn enables the coordination of individual efforts globally in dynamically matching current production decisions with future consumption needs in commodities. The price risk management benefits of these markets were also emphasized in this chapter.

One should note that concerns with past oil price spikes are fully justified. One can be worried, though, that proposals to restrict speculation may actually be placeboes that distract from addressing the real causes of past price spikes. One hopes that advisers to influential policymakers will do careful research on the economic theory and practice of commodity futures markets before advocating draconian position limits within these markets.

That said, one must acknowledge that public scrutiny of, and skepticism about, commodity futures markets has had a long tradition in both the United States and in Continental Europe, dating back to (at least) the last great era of globalization in the 1890s. Over the past 120 years, two efforts have historically prevented futures trading from generally being banned or heavily restricted. The first supportive factor has been a general (although not unanimous) recognition by policymakers that futures markets serve a legitimate social purpose. The second factor has been to base public policy on an objective examination of extensively gathered facts, which are summarized via appropriate statistical measures. One could argue that it would be wise to re-examine these historical lessons. Therefore, given the re-emergence of controversies over commodity futures trading, including in the oil markets, this chapter provided an updated primer on the economic functioning of commodity futures markets with the hope of further informing the public debate on these markets.

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Biography

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The Influence of Renewables on the German Day Ahead Electricity Prices 10

Nabi Adaduldah, André Dorsman, Geert Jan Franx, and Paul Pottuijt

Abstract

During the last 5 years European wholesale electricity markets have been confronted with a rapid increase in Renewable Energy Source (RES)-generation. RES-generation is characterized by (1) more decentralized production at typically dissimilar locations compared to traditional production and (2) more intermittent patterns of production depending on weather conditions. This chapter will focus on solar and wind energy, which have in common that they cannot be ordered to our disposal when we need them. However, the share of these renewables in the total energy supply in Germany has increased to such levels that the electricity prices on the day ahead spot market depend highly on the expected supply of solar and wind energy. In addition, regulations in favor of RES-generation in Germany have forced the Transmission System Operators (TSOs) to use all generated solar and wind energy. On windy and sunny days this has led to some exceptional cases of negative energy prices. This chapter identifies the influence of solar and wind energy supply on day ahead electricity prices.

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10.1 Introduction

There are three main developments that have had a substantial impact on the energy market. The first development is the growing supply of shale gas and oil.[1] The second development is market coupling. In Europe we see that former nationally organised markets are linked together.[2]

The third main development is the shift away from traditional power sources towards intermittent renewable sources of power, which is the topic of this chapter. In this chapter we discuss the impact of the growing emphasis on supply of wind and solar energy. Wind and solar energy are fundamentally intermittent and unpredictable sources of power due to their dependence on the weather. Wind turbines are currently designed to withstand maximum wind speeds of about 25 m per second. At higher wind speeds, the turbines are switched off for safety reasons (Laughton 2007).

The price of electricity is very volatile. Market coupling reduces price volatility, while RES-generation has the opposite effect. In this chapter we will look at the impact of the shift from fossil fuels to renewables on day ahead energy prices.

In Europe, Germany is taking the lead in the switch from fossil and nuclear energy to renewables. This shift got a large push forward when the German government decided to slowdown nuclear energy as a reaction to the Fukushima nuclear disaster in 2011. In this chapter we will look at the influence of wind and solar energy on electricity prices in Germany.

In the past, electricity prices were higher during peak hours (between 08:00 and 20:00 h) than during off peak hours (other hours). The reason was that consumption during peak hours is substantially higher than during off-peak hours, while the supply of electricity is less flexible. However, the sun shines – if it shines – during daytime. Also, winds are mostly stronger during the day than during the night. In other words, during peak hours the supply of wind and solar energy may be very large, which would result in lower electricity prices.

During sunny and windy days the peak price can be lower than the off-peak price. The consequences are clear. Up to now we had futures that could be exercised only during the peak hours and futures that could be exercised only during the off-peak hours. Now that we are no longer sure that the peak price will be higher than the off peak price, the price difference between both types of futures will diminish or even disappear.

The structure of this chapter is as follows. In Sect. 10.2 we discuss general developments in future energy supply. Section 10.3 describes the developments of RES-generation and market developments. In Sect. 10.4 we present the data. Section 10.5 contains the empirical results and -Sect. 10.6 the conclusion.

[1] In Chap. 6, Kolb gives an analysis of the gas market.

[2] In the first CEVI books *Financial Aspects in Energy* and the second CEVI book, *Energy Economics and Financial Markets*, attention was paid to this topic by Dorsman, van Montfort and Pottuijt (2011) and Dorsman, Franx and Pottuijt (2011) respectively.

10.2 Developments

Due to the increased production of shale gas and oil, the U.S. will be self-supporting in gas in several years from now and in oil at the end of this decennium. The U.S. Energy Information Administration (EIA) estimates that the United States possesses more than 2,500 trillion cubic feet of technically recoverable natural gas resources, of which 33 % is held in shale rock formations. According to the EIA (2013a), natural gas from shale has grown to 25 % of U.S. gas production in just a decade and will reach 50 % by 2035. Developing this resource can help the U.S. to enhance its energy security and strengthen its economy. The economic consequences might be substantial if energy-intensive industries relocate their production capacity back to U.S. territory.

For fear of environmental consequences, Europe has been hesitant to follow the U.S. in the production of shale gas and oil by means of hydraulic fracturing (fracking).[3] This method is used to extract natural gas from shale rock formations in which it is trapped. The process requires engineers to drill a hole deep into the rock where the gas is trapped, and then inject a mixture of sand, water and chemicals into the hole at an extremely high pressure (EIA 2013b). This causes the rock to split, releasing the gas into the well so that it can be brought up to the surface. The use of chemicals might bring a risk of contaminating the supply of drinking water, which makes fracking a subject of debate in many European countries.

An important difference between the U.S. and Europe is the ownership of the shale gas. In the U.S., the land-owners will benefit from the revenues of winning shale gas, and there usually are not too many incentives for them to investigate the environmental consequences thoroughly. However, in Europe, governments own the shale gas. Therefore, in many European countries both the benefits and the drawbacks of extracting shale gas are subject to lively political debates, and a lot of environmental research is done before decisions are taken.

The consequences of the differences in shale gas and oil production between the U.S. and Europe are visible today. The spread between WTI (West Texas Intermediate), indicator for oil prices in the U.S., and Brent Oil, indicator for oil prices in Europe, is now larger than before, as shown in Fig. 10.1.

Van der Hoeven (2013) writes that the sale of US crude overseas is governed by the Export Administration Act of 1979, which allows the president of the US to prohibit or to curtail the exports of commodities – namely crude oil – deemed to be in "short supply". However, the increasing supply of shale gas and oil has made that "short supply of crude" disappear. Nevertheless, the export of gas and oil from the U.S., is still forbidden, which causes lower gas and oil prices in the U.S.

[3] For example, President Francois Hollande of France said in July 2013 that due to possible pollution effects, he will not allow any research on the possibility of producing shale gas in France during his presidency.

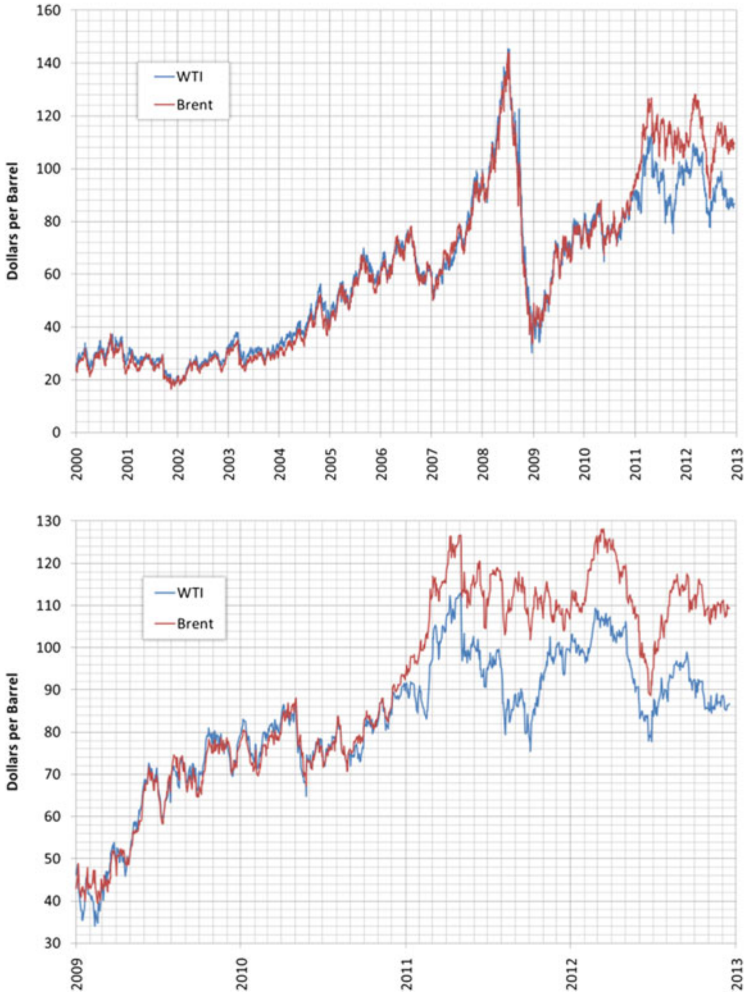

Fig. 10.1 The difference between WTI and Brent Oil prices (EIA 2012)

Another imperfection in the U.S. gas and oil market is the infrastructure. The shale fields of North Dakota, for example, are far from places where shale gas is consumed in the U.S. The rapid growth in the supply of shale gas and oil exceeds the pace at which the infrastructure can be improved.

A second major development is market coupling. Since the beginning of the twenty-first century European wholesale electricity markets have been in transition towards free markets *(liberalization & privatization)* and market integration *(the development from individually organized trading markets per country toward one integrated European energy market)*. Especially the developments of market integration, by means of so-called market coupling, have demonstrated that enlarged and integrated trading regions lead to fewer market imperfections, more price convergence and lower market volatility (Dorsman et al. 2011, 2012).

EU policy goals to lower CO_2 emissions, lower dependency on fossil fuels, technological developments and falling production costs contribute to the rapid increase in RES-generation. However, there are fundamental differences between the locations of traditional power generation and RES-generation. Transmission systems that need to ensure that electricity production is at any moment in balance with electricity consumption are nowadays challenged to keep on meeting this technical requirement under changed circumstances.

For the Transmission System Operators (TSOs), the shift from fossil and nuclear fuels towards renewables is not complicated in all situations. For renewables like hydropower and biomass there are storing possibilities. However, these possibilities are not directly available for wind and solar energy. The highest growth rate in energy production is in wind and solar energy, which makes the tasks of the TSOs difficult.

As this shift occurs, there are some concerns. One concern is where wind turbines are made. Wind turbines are necessary for the production of wind energy. In some years, Chinese companies have taken the lead in the production of wind turbines.

Table 10.1 shows that the largest manufacturer of wind turbines is the Danish company Vestas. However, the market share of Vestas is decreasing rapidly and its survival is at stake. Despite the below-average quality of their wind turbines, government subsidies have allowed Chinese companies to offer lower prices and to increase their market shares very rapidly. It seems that Chinese companies will take over the wind market as they did the solar market. Europe's increasing dependence on Chinese products for renewables is also decreasing the certainty of delivery.

Another concern is maintaining the grid in balance. Figure 10.2 gives an overview of the German transmission grid. Over the last 10 years, the grid has become heavily loaded and congested due to the tremendous increase of RES-generation – especially large wind parks – being connected to the grid in Northern Germany. On windy days, production significantly exceeds consumption in the North of Germany. Consequently, the surplus needs to be transmitted to other regions. However, in an increasing number of cases, connections with adjacent transmission grids lack the required capacity. The system simply was not designed with RES-generation in mind, but with the expectation that within a grid demand would always be balanced via 'traditional' and more controllable generation methods (coal, nuclear, gas, hydro, etc.).

Bach (2012) points out that most of German wind power is installed in the north, while solar capacity is mainly installed in the south. The reduction in the supply of nuclear energy has caused problems mostly in the south. However, as Bach (2012)

Table 10.1 Producers of wind turbines in 2011

Company	Country	Production (in MW)	Market share
Vestas	Denmark	5,217	12.7
Sinovel	China	3,700	9.0
Goldwind	China	3,600	8.7
Gamesa	Spain	3,308	8.0
Enercon	Germany	3,203	7.8
GE Energy	USA	3,170	7.7
Suzlon	India	3,166	7.6
Guodian United Power	China	3,042	7.4
Siemens	Germany	2,591	6.3
Mingyang	China	1,500	3.6

Source: *Financieele Dagblad*

Fig. 10.2 German power corridors (Bach 2012)

notes, in the winter solar energy cannot satisfy the need for electricity during the evening peak load.

There are basically two main alternatives to address the situation described above:

1. **Increase transport capacities between (and within) transmission- and distribution grids**.
   This is the quick and theoretically obvious alternative. In practice, however, it cannot be implemented easily and certainly not in a timely manner – it is already needed today. The technology and the planning needed for adding grid capacity

is very complex, investments required are very high (billions of euros), and spatial planning procedures are very lengthy, etc. Given such big and time consuming hurdles for increasing transmission capacities, this is a topic high on political agendas because a strong grid infrastructure, which facilitates the electricity flows coming from RES-generation, is a key and indispensible element of the ongoing 'Energy Transition'.[4]

2. **Manage the production-consumption balance within a grid**.
As described above, if it is not possible to increase transportation capacities in the short term, it is unavoidable that the production-consumption balance be managed within a grid. Electricity cannot be stored and production consumption must be in balance at all times. Otherwise, grid stability will be at risk ('blackout'). Given that the energy generation sector no longer is a centrally operated (semi-governmental) activity, but a full free-market activity, management of the supply-side ideally should be market-based whereby market forces lead to demand and supply balance. In a liberalized market, it is not desirable for the TSO (not being a market player, but a regulated activity) to intervene with security measures (such as remedial actions) if it is no longer possible to guarantee system balance.
Currently, in European energy markets there are mechanisms in place that contribute to the production-consumption balance. For example, in Germany, where the main issues are with RES-generation (see earlier example), RES-generation gets a priority above conventional generation methods. In cases of high RES-generation, German wholesale prices drop to very low levels because marginal costs of RES-generation are much lower than conventional generation. There also can be so much overproduction due to the RES-generation that negative energy prices may be required to restore the production-consumption balance. In this case there is so much overproduction that parties get paid to consume electricity or get paid to not produce (conventional) energy they already sold (and for which they still will be paid, even without delivery).

This chapter discusses the problems of market integration due to the developments in RES-generation. The shift from conventional power production (such as nuclear, coal and gas) to wind and solar energy influences market integration. Likewise, the degree of market integration influences the shift from conventional to renewable power generation.

[4] *Transition away from fossil fuels driven by a desire for lower dependencies on foreign fossil fuel suppliers, increased usage of renewable energy sources, concerns with climate change and the depletion of fossil fuels.*

10.3 RES-Generation and Market Developments

After the earthquake of Japan on March 11, 2011 the nuclear plant in Fukushima was damaged seriously and for many weeks a meltdown was a real threat. Countries reacted differently. Germany decided to close down several nuclear plants and to increase RES-generation to 80 % of total supply of electricity by 2050, while at this moment (2012) it is only 12 %. Turkey, on the other hand, decided to build new nuclear power plants because, Prime Minister Erdogan claimed, the country needs all the available supply of energy to sustain economic growth. These different reactions to the Japanese problems are special, because the probability of an earthquake in Germany is very small and in Turkey it is very large.

From the beginning of this century Germany had the lead in renewables in Europe. A new industry developed around the supply of renewable energy. German companies became world leaders as producers of solar energy and many wind mill parks were developed. After the change in energy policy in 2011, the so-called *Energiewende* (energy shift), Germany wants to speed up this process of switching from nuclear and fossil energy to renewables. This switch is causing some problems that we will describe in this chapter.

Currently, the development of RES-generation is continuing, whilst the required increases in transmission capacities are not expected within the very short term. Together with some other factors that we elaborate below, this has an effect on price formation in wholesale energy markets that one could observe already over the last half-decade.

The two main drivers of changes in energy price formation over the last decade (with increasing impact during that period) are the following:

1. **Increase of RES-generation via solar electricity production**.

   In Europe, over the last 5 years, solar energy production has increased very rapidly. In some markets production increased significantly more. In the German market, in particular, the stimulation of RES-generation, combined with technological improvements and the lower cost of building solar production facilities, has led to a major increase in solar power production over the last 5 years (see Fig. 10.3).

   Given the link between the level of solar energy production and the amount and intensity of sunshine, solar energy production reaches its maximum in the early afternoon and is highest during the summer.

   Before the advent of solar energy, wholesale energy prices would peak around the times when the production of solar energy reaches a maximum. Today, however, peak prices are much lower on sunny days and there are even instances when peak prices drop below base-load prices. Growing RES-production can therefore reduce the price-differences between peak and off peak prices.

   The level of solar- and wind-production facilities in Germany at this time is such that on windy days with a lot of sunshine that coincide with days when traditionally demand is low (for instance, on Sundays or bank-holidays), the amount of energy produced by RES-generation exceeds consumption. Such situations affect not only technical transmission, but also price formation.

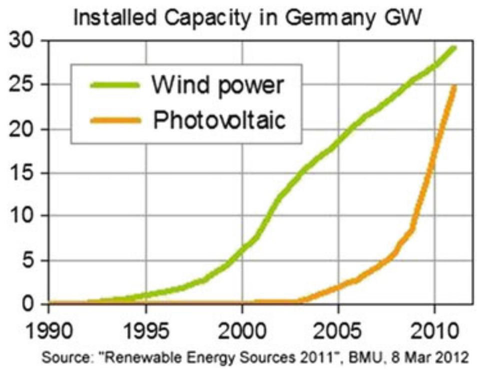

Fig. 10.3 The installed capacity of wind and solar energy in the period 1990–2010

2. **The unexpected shut-down of nuclear generation facilities in Germany**. After the nuclear disaster in Japan in March 2011, the German Parliament decided to shut down immediately eight big nuclear power plants and has planned to shut down the remaining German nuclear power plants in the period 2012–2022. As one can expect, this decision affects wholesale energy market price formation: Until the shut-down, due to its technological characteristics (it is not a flexible production method) and price characteristics (it has low marginal costs), nuclear power generation had been a significant and stable base contributor to energy production.

   These developments make the need for additional transmission and production capacity within Germany more immediate. Wind production, which is concentrated in northern Germany, is the major contributor to overproduction, whereas the nuclear power shut-down mainly takes place in the south. The shut-down of a very significant, stable and low cost source of energy has created needs for extra production and interregional transmission capacity. The fact that the southern part of Germany has a problem that can be solved with a problem that occurs in the north (or vice versa), but currently is blocked by the sufficient availability of transmission capacity within the country, creates much political pressure in Germany to quickly resolve these production and transmission bottlenecks.

For a long time, Germany had a more-or-less predictable supply of electricity (nuclear, oil, gas and coal). However, due to the closing of German nuclear power plants and the increased share of RES-generation, the supply of electricity has become more volatile and the task of the TSO to keep the grid in balance has become more complicated. Figure 10.3 shows the installed capacity of wind and solar energy in Germany. This graph shows that installed capacity – especially in solar energy – increased very rapidly after 2007.

Mulder and Scholtens (2013) look at the influence of wind and solar energy in the Dutch day-ahead electricity market APX (Amsterdam Power Exchange) for the period 2006–2011. They argue that German climate conditions (wind and sun) are important because the magnitude of the cross-border transport capacity between the

Table 10.2 Descriptive statistics of realized day-ahead price, expected solar energy supply, expected wind energy supply and total volume traded on the day ahead market

Descriptive statistics			
	N	Mean	Std. Deviation
Price (EUR/MWh)	17,544	46.8535	16.8906
Sun (GW)	17,544	2.7049	4.1401
Wind (GW)	17,544	5.2921	4.3214
Volume (GWh)	17,544	26.7795	4.7773

Netherlands and Germany is large and is the equivalent of 15 % of Dutch peak demand. Based on their data and the fact that the supply of wind energy in the Netherlands is very limited, they conclude that the wind speed in Germany is more important for the Dutch electricity price than the wind speed in the Netherlands. Mulder and Scholtens did not find significant influence of solar irradiation in the Dutch electricity price. They conclude that although there is a strong increase in wind and solar energy in Germany, conventional power plants remain the decisive factor.

In their analysis, Mulder and Scholtens use daily data. In this chapter we are using (adjusted) hourly data. This difference is important because the supply of solar energy as well as wind energy changes throughout the day. Therefore, we are able to research issues in greater detail.

10.4 Data

In our research we use the realized German day-ahead prices[5] and the expected day-ahead supply of wind and solar energy. The period of observation spans 2011 and 2012. On the day-ahead power exchange, the prices for day $t + 1$ are fixed on day t. By doing so, the TSO (Transmission System Operator) – who is responsible for the demand and supply on the grid being in balance – is able to manage the positions on the grid the following day. To facilitate the price formation process, detailed predictions for solar and wind energy production for day $t + 1$ are released on day t. Consequently, expected solar and wind energy supply may influence day-ahead prices.

On the day-ahead power exchange, spot prices are fixed for every hour of the next day. However, the expected solar and wind energy dataset contains the day-ahead predictions for every quarter of an hour. In our analysis, we calculate hourly data for the expected solar and wind energy supply by averaging four quarters of data.

Table 10.2 contains the descriptive statistics of the price of electricity, the expected supply of solar energy, the expected supply of wind energy and the total electricity volume traded on the day ahead market (total volume). The supply of

[5] We thank Mr. Khou, Powernext, for providing us is with the data necessary for this research.

Table 10.3 The parameters of Eq. 10.1

Model summary[a]						
Model		R	R Square	Adjusted R square	Std. Error of the estimate	
1		0.433[b]	0.188	0.188	15.22378	
ANOVA[a]						
Model		Sum of squares	df	Mean square	F	Sig.
1	Regression	939,737.313	3	313,245.771	1,351.575	0.000[b]
	Residual	4,065,131.691	17,540	231.763		
	Total	5,004,869.004	17,543			

Coefficients[a]							
		Coefficients				Collinearity statistics	
Model		B	Std. Error	t	Sig.	Tolerance	VIF
1	(Constant)	14.177	0.966	14.669	0.000		
	Sun (GW)	−1.211	0.045	−27.193	0.000	0.389	2.572
	Wind (GW)	−2.447	0.040	−61.931	0.000	0.453	2.207
	Volume (GWh)	1.826	0.045	41.020	0.000	0.292	3.423

[a]Dependent Variable: Price (EUR/MWh)
[b]Predictors: (Constant), Volume (GWh), Wind (GW), Sun (GW)

wind energy is more than twice the supply of solar energy, despite the fact that the installed (maximum) capacities for wind energy and for solar energy were more or less the same (see Fig. 10.3). This is caused by the fact that the sun shines no more than 50 % of the time.

10.5 Empirical Research

For the years 2011 and 2012, we estimated the equation (Table 10.3)

$$P_t = a + b_1\, sun_t + b_2\, wind_t + b_3 vol_t + \varepsilon_t \tag{10.1}$$

where

P_t = the realized day-ahead electricity price in hour t
sun_t = the expected supply of solar energy in hour t in GW
$wind_t$ = the expected supply of wind energy in hour t in GW
vol_t = the realized trade volume of energy in hour t in GWh

With these coefficients, our estimated model becomes:

$$P_t = 14.177 - 1.211\, sun_t - 2.447\, wind_t + 1.826\, vol_t \tag{10.2}$$

This equation shows how every extra expected MWh of solar and wind energy supply influences price. Both types of supply have a significant negative influence on energy prices. The impact of wind energy on the electricity price is larger than the impact of solar energy. Although the adjusted R^2 is only 0.188, this model

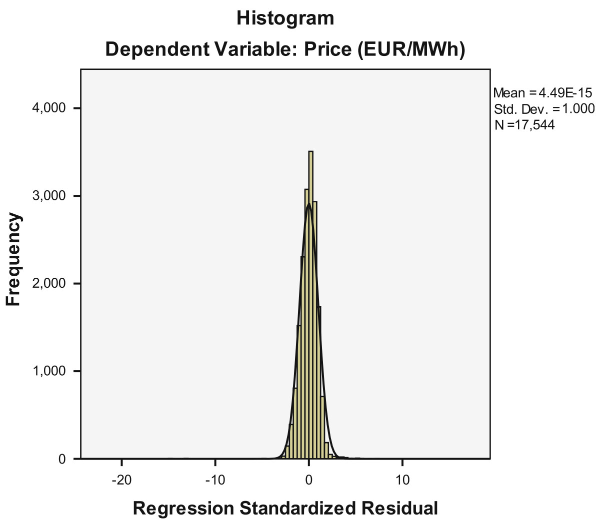

Fig. 10.4 Histogram of the residuals

Table 10.4 Correlation coefficients of price, solar energy supply, wind energy supply and total trade volume

	Price	Sun	Wind	Volume
Price	1.000	0.090	−0.327	0.018
Sun	0.090	1.000	−0.120	0.604
Wind	−0.327	−0.120	1.000	0.509
Volume	0.018	0.604	0.509	1.000

shows that yields from wind and solar sources do influence the price of electricity. Figure 10.4 shows the regression standardized residual. The deviations of this distribution from the normal distribution are non-problematic.

Table 10.4 presents the correlations between the variables of Eq. 10.1. The correlation between the (expected) supply of wind energy and the price of electricity is negative. This is what one would expect, since a higher supply of wind energy will lead to lower prices. However, the correlation between the (expected) supply of solar energy and the price of electricity is positive. At first sight, this seems strange, but it isn't. For the electricity market we distinguish between peak and off-peak hours. The peak hours are from 8:00 (a.m.) to 20:00 (p.m.) and the remaining hours are off-peak hours. Demand during peak hours is substantially larger than during off-peak hours, which causes higher prices during peak hours. The sun shines during the daytime (mostly peak hours) and not during the night time (mostly off peak hours). Therefore, we find a positive correlation between the (expected) price of solar energy and energy prices.

These correlations indicate that solar energy is usually sold at higher prices than wind energy, just because the sun happens to shine primarily during the peak hours. Therefore, it may be profitable to invest in storage facilities for renewable energy, which make it possible to sell most of it during peak hours. This is especially attractive for wind energy. Nowadays, in northern Germany, wind energy suppliers

Table 10.5 The parameters of the model with off peak dummy and interaction variables

Model summary[a]

Model	R	R square	Adjusted R square	Std. Error of the estimate
1	0.561[b]	0.315	0.315	13.98102

ANOVA[a]

Model		Sum of squares	df	Mean square	F	Sig.
1	Regression	1577125.730	7	225303.676	1152.632	0.000[b]
	Residual	3427743.275	17,536	195.469		
	Total	5004869.004	17,543			

Coefficients[a]

Model		Unstandardized coefficients				Collinearity statistics	
		B	Std. Error	t	Sig.	Tolerance	VIF
1	(Constant)	39.687	1.331	29.809	.000		
	Sun (GW)	−1.881	.047	−40.387	.000	.300	3.338
	Wind (GW)	−2.057	.049	−42.132	.000	.250	3.997
	Volume (GWh)	1.154	.056	20.730	.000	.157	6.350
	Off peak (dummy)	2.760	1.998	1.381	.167	.011	89.574
	OffPeak*sun (GW)	3.278	.321	10.216	.000	.926	1.079
	Offpeak*Wind (GW)	.206	.074	2.777	.005	.134	7.489
	OffPeak*Volume (GWh)	−.826	.090	−9.152	.000	.009	108.036

[a]Dependent Variable: Price (EUR/MWh)
[b]Predictors: (Constant), OffPeak*Volume (GWh), Wind (GW), OffPeak*sun (GW), Sun (GW), Volume (GWh), Offpeak*Wind (GW), Off peak (dummy)

are already investing in facilities for this purpose. Most of these facilities use the technology of electrolysis in order to change water into hydrogen and oxygen. The energy stored in the hydrogen and oxygen gas can be released during peak hours by the inverse electrolytic process.

Since the demand for energy depends highly on the time of day, it makes sense to make a distinction between peak hours (8:00–20:00) and off-peak hours. For this purpose we added the dummy variable ‘Off Peak’ and the corresponding interaction variables ‘OffPeak*Sun’, ‘OffPeak*Wind’, and OffPeak*Volume. This leads to the model parameters in Table 10.5.

First of all, the increase of R^2 (from 0.188 to 0.315) indicates a larger explanatory power of this extended model. In other words, the model explains 31.5 % of the price variance.

The value of the Off Peak dummy coefficient can be interpreted as a correction on the constant during off-peak hours. This correction turns out not to be statistically significant. However, the corrections on the slope coefficients during off peak hours are significant, as can be seen from the slope coefficients of the interaction terms. Especially the slope correction for the expected solar energy (OffPeak*sun) is so positive (3.278) that we must conclude that during off-peak hours there will be a positive influence of expected solar energy supply on energy prices (with slope

Table 10.6 Model with morning and evening dummy and interaction with wind and sun

Model summary[a]

Model	R	R square	Adjusted R square	Std. Error of the estimate
1	.613[b]	.375	.375	13.35421

ANOVA[a]

Model		Sum of squares	df	Mean square	F	Sig.
1	Regression	1,877,943.019	9	208,660.335	1,170.047	.000[b]
	Residual	3,126,925.985	17,534	178.335		
	Total	5,004,869.004	17,543			

Coefficients[a]

Model		Unstandardized coefficients				Collinearity statistics	
		B	Std. Error	t	Sig.	Tolerance	VIF
1	(Constant)	50.641	1.038	48.770	.000		
	Sun (GW)	−1.612	.041	−39.703	.000	.360	2.781
	Wind (GW)	−1.758	.042	−41.521	.000	.304	3.293
	Volume (GWh)	.682	.043	15.949	.000	.243	4.108
	Morning (dummy)	−18.848	.441	−42.759	.000	.235	4.248
	Evening (dummy)	−9.491	.517	−18.353	.000	.274	3.654
	Morning*Sun (GW)	4.935	.317	15.555	.000	.917	1.091
	Morning*Wind (GW)	−.533	.054	−9.896	.000	.307	3.252
	Evening*Sun (GW)	−.865	1.898	−.456	.648	.927	1.079
	Evening*Wind (GW)	.114	.068	1.679	.093	.329	3.043

[a]Dependent Variable: Price (EUR/MWh)
[b]Predictors: (Constant), Evening*Wind (GW), Volume (GWh), Morning*Sun (GW), Evening*Sun (GW), Morning*Wind (GW), Sun (GW), Evening (dummy), Wind (GW), Morning (dummy)

coefficient −1.881 + 3.278 = 1.397). This appears to be unreasonable. If there is an increase in solar energy supply, one would expect the energy price to drop.

Another unwanted feature of this model is the collinearity between the OffPeak dummy and the Offpeak*Volume interaction variable, which is reflected in very high variance inflation factors of 89.574 and 108.036. This collinearity is caused by the fact that there is not much variation in the trade volume during off peak hours. We have to keep in mind that this volume does not equal the total demand. It is in fact only the amount of energy that has not yet been sold 1 day ahead of actual production and demand. Since accurate demand predictions are made a long time ahead of the delivery date, the majority of the demand for energy can and will be contracted a long time before the actual production and consumption date. Therefore, the (trade) volume on the day-ahead power exchange is by no means a good measure for the total demand and the scarcity of electrical energy.

In order to eliminate the collinearity and to analyse what is causing the positive slope coefficient during off-peak hours, we decided to leave out the interaction variables incurring trade volume, and to split up the off-peak hours into evening

Table 10.7 Model with morning and evening dummy and interaction, and hour 8 dummy

Model summary[a]

Model	R	R square	Adjusted R square	Std. Error of the estimate
1	.632[b]	.400	.400	13.08746

ANOVA[a]

Model		Sum of squares	df	Mean square	F	Sig.
1	Regression	2,001,786.801	10	200,178.680	1,168.710	.000[b]
	Residual	3,003,082.203	17,533	171.282		
	Total	5,004,869.004	17,543			

Coefficients[a]

Model		Unstandardized coefficients				Collinearity statistics	
		B	Std. Error	t	Sig.	Tolerance	VIF
1	(Constant)	53.623	1.024	52.385	.000		
	Sun (GW)	−1.538	.040	−38.549	.000	.358	2.794
	Wind (GW)	−1.677	.042	−40.305	.000	.302	3.310
	Volume (GWh)	.554	.042	13.120	.000	.240	4.162
	Morning (dummy)	−19.835	.434	−45.751	.000	.234	4.278
	Evening (dummy)	−9.711	.507	−19.159	.000	.274	3.655
	Morning*Sun (GW)	−1.483	.392	−3.783	.000	.577	1.733
	Morning*Wind (GW)	−.628	.053	−11.876	.000	.306	3.267
	Evening*Sun (GW)	−.920	1.860	−.495	.621	.927	1.079
	Evening*Wind (GW)	.104	.066	1.564	.118	.329	3.043
	Hour 8 (dummy)	17.675	.657	26.889	.000	.566	1.767

[a]Dependent Variable: Price (EUR/MWh)
[b]Predictors: (Constant), Hour 8 (dummy), Wind (GW), Evening*Sun (GW), Sun (GW), Evening*Wind (GW), Morning*Wind (GW), Morning*Sun (GW), Evening (dummy), Volume (GWh), Morning (dummy)

hours (20:00–24.00) and morning hours (0:00–08:00), which resulted in the model parameters in Table 10.6.

Again, the model fit has improved, as reflected in R^2, which has increased from 0.315 to 0.375. The removal of the trade volume interaction variable has led to a complete elimination of all collinearity problems (all VIF values < 5). However, a remaining unwanted feature of this model is the large positive slope coefficient correction, reflected in Morning*Sun. This correction implies (an even larger) positive slope coefficient of $-1.612 + 4.935 = 3.323$ for expected solar energy during the morning hours. On the other hand, during the evening hours the Sun slope coefficient does not differ significantly from its negative value during peak hours, which is reasonable. This indicates that the problem with the positive slope coefficient is caused during the morning hours. It is interesting to note that we do not have this problem with respect to expected wind energy.

During a thorough analysis of the raw data, we observed a significant difference between the transition from morning to peak hours as opposed to the transition from

Table 10.8 Model with morning and evening dummy and interaction, and hour 7 and 8 dummies.

Model summary[a]

Model	R	R square	Adjusted R square	Std. Error of the estimate
1	.639[b]	.408	.408	12.99864

ANOVA[a]

Model		Sum of squares	df	Mean square	F	Sig.
1	Regression	2,042,578.683	11	185,688.971	1,098.980	.000[d]
	Residual	2,962,290.321	17,532	168.965		
	Total	5,004,869.004	17,543			

Coefficients[a]

Model	Unstandardized coefficients				Collinearity statistics	
	B	Std. Error	t	Sig.	Tolerance	VIF
1 (Constant)	53.875	1.017	52.983	.000		
Sun (GW)	−1.532	.040	−38.652	.000	.358	2.794
Wind (GW)	−1.670	.041	−40.412	.000	.302	3.310
Volume (GWh)	.543	.042	12.949	.000	.240	4.163
Morning (dummy)	−20.916	.436	−47.953	.000	.228	4.390
Evening (dummy)	−9.730	.503	−19.327	.000	.274	3.655
Morning*Sun (GW)	−2.688	.397	−6.772	.000	.555	1.802
Morning*Wind (GW)	−.643	.053	−12.230	.000	.306	3.268
Evening*Sun (GW)	−.925	1.847	−.501	.617	.927	1.079
Evening*Wind (GW)	.103	.066	1.563	.118	.329	3.043
Hour 8 (dummy)	20.096	.671	29.941	.000	.535	1.868
Hour 7(dummy)	8.229	.530	15.538	.000	.860	1.163

[a]Dependent Variable: Price (EUR/MWh)
[b]Predictors: (Constant), Hour 7(dummy), Wind (GW), Hour 8 (dummy), Evening*Sun (GW), Sun (GW), Evening*Wind (GW), Morning*Wind (GW), Morning*Sun (GW), Evening (dummy), Volume (GWh), Morning (dummy)

peak to evening hours. Energy prices increase extremely fast between 6:00 and 8.00 (a.m.), whereas the drop in prices in the evening is much more gradual. In fact, energy prices from 7:00 to 8:00 (a.m.) are almost at the same level as during peak hours. Therefore, we decided to add an extra dummy variable for hour 8 (from 7:00 to 8:00 a.m.) to correct for the steep energy price increase during this hour. This results in the model parameters in Table 10.7.

We observe a further increase in R^2, which indicates that now 40.0 % of the price variance is explained by the model. Moreover, the slope coefficient for predicted solar energy that was positive during morning hours has turned negative, as it should be. We also observe that the constant for hour 8 has now become 53.623 – 19.835 (correction for morning) + 17.675 (correction for hour 8), which is in agreement with the fact that energy prices during hour 8 are almost as high as during peak hours.

To ascertain the influence of the rather abrupt price increase during hour 7, we also added a dummy variable for this hour in the model (Table 10.8).

Adding another dummy, now for hour 7, further increases the R^2. Now 40.8 % of the price variance is explained by the model. We found out that adding more dummies for separate hours is not very useful, which is in agreement with the observation that hour 7 and 8 are the only hours with a relatively high energy price deviation (compared to the other off peak hours).

Now that we know about the sudden increase in energy prices between 6:00 and 8:00 (a.m.), we can explain the positive slope coefficient for expected solar energy that we initially found for morning hours. This price increase is not caused by an increase in solar energy, but by a sudden increase in total demand. In fact, we are surprised that hour 8 is called an off-peak hour, since the average price level at this hour is much closer to the peak-hour price level. The occurrence of a positive slope coefficient for expected solar energy during morning hours is caused by the fact that both solar energy and energy prices increase suddenly from 6:00 to 8:00 (a.m.). Without total demand as an explanatory variable in our model, the model will incur a positive slope coefficient for solar energy to explain the sudden price increase. Since the price drop in the evening is much more gradual, we did not encounter this phenomenon during evening hours.

Summary and Conclusion

This chapter identified changes in electricity prices based on current developments within European energy markets. One current development is, among others, the increased intake of generation from Renewable Energy Sources (RES). We gathered and analyzed historical market prices and RES-generation volume data from Germany to show what impact this development had on the energy market. Our analysis shows that every extra unit of power generated by solar or wind has a negative influence on the price for electricity. All public and private participants in the markets should take this into account.

We found strong evidence that solar energy and wind energy have a negative impact on the electricity price in Germany. This result calls for more detailed studies. For example, the supply of solar energy is mostly limited to peak hours. In the past we saw that peak prices are higher than off-peak prices. However, a substantial supply of solar energy can push the peak price below the off-peak price. Another issue is the impact of renewables on electricity prices in adjacent grids. Due to market coupling, a number of European national grids are now linked. As a result, an additional supply of solar and wind energy in one European country may influence the demand/supply balance of electricity in another country.

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Corporate Financing and Investment Decisions in the Renewable Energy Sector

11

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Abstract

Increasing investments in renewable energy (RE) are expected to contribute to the growth of the energy sector as a whole, and thus to general economic growth. Recent research indicates that increasing investments in RE has several potential benefits such as achieving sustainable economic recovery from the financial crisis, ensuring a country's energy security, and fighting climate change and environmental pollution. Apart from public support in the form of energy policies and mechanisms such as governmental grants and subsidies, the growth of the RE sector largely depends on private external financing. This chapter analyzes the corporate financing and investment activities of RE companies by focusing on firm-level and country-level factors. An investor protection perspective is taken when choosing the country-level factors, since the type of external financing obtained by companies is largely driven by outside investors' willingness to supply it. Given the growth opportunities of firms, the evidence indicates the importance of the relationship between debt level and investment.

11.1 Introduction

Renewable energy (RE) has been growing in importance around the globe because it promises a more secure supply of energy, independence from fossil resources and a decrease in carbon dioxide (CO_2) emissions. As such, growth in RE can solve the problem of energy security and address the need for long-term economic recovery and growth, and reduce environmental pollution (Houser et al. 2009; Chaurey

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et al. 2003). Houser et al. (2009) allege that with a consistent energy policy, investment in RE will create more permanent employment benefits in the long-run (30,000 jobs for each US $1 billion government investment), lower the cost of energy, reduce CO_2 emissions and provide energy security as compared with a similar investment in fossil-fuel sources. However, investments in this sector require raising vast amounts of funds. Thus, firms in this sector need to obtain external financing for their long-term and riskier investments to produce clean energy.

The focus of this chapter is to incorporate the role of a country's institutional factors to analyze the financing and investment decisions of RE companies. The theory of Modigliani and Miller (1958) suggests that in an ideal world without taxes, where capital markets are operating perfectly, financing decisions are irrelevant for a firm's investment decisions. However, theoretical and empirical research has demonstrated the interdependence between financing and investment decisions. Imperfect capital markets and the existence of taxes lead firms to consider their financing choices in their investment decisions and even to make both decisions simultaneously (McCabe 1979). Due to the presence of transaction costs, asymmetric information, and agency problems, corporate financing and investment decisions interact with each other (Dang 2011; Aivazian et al. 2005). The financing choice of a firm is related to its investment decisions based on whether the firm anticipates future growth and has valuable investment opportunities. In addition, being financially flexible by maintaining a conservative financial policy can enhance the investment ability of firms that have good growth opportunities (Lang et al. 1996; Marchica and Mura 2010; Minton and Wruck 2001). The conclusion is that a firm's financing choices determine its investment decisions and consequently the firm's growth through the interaction of existing valuable growth opportunities.

This chapter aims to identify factors stimulating investments in the RE sector. If governments undertake no changes in existing economic and energy policies, the share of renewable energy sources (such as hydro, biomass, waste, solar, wind, geothermal, tidal and wave) is projected to grow from about 12 % in 2007 to 14 % in 2030, with non-hydro sources exhibiting the highest growth in comparison to hydro, nuclear and conventional energy sources about 7.3 % growth per year. However, despite its dynamic growth, the RE sector is still projected to account for less than 15 % of global energy demand while fossil fuels, with an 80 % share, will retain their position as the dominant source of energy (International Energy Agency [IEA] 2009).

In the literature, there is a lack of research on the interdependence between financing and investment decisions for RE companies, and how the institutional and legal environments related to investor protection affect this relationship. Previous research on determining the factors that affect the development of the RE sector has focused on analyzing the relationship between the growth of the RE sector and a country's economic growth. The main driver of the growth of the RE sector is a country's GDP. Other variables often deemed important in explaining the relationship are CO_2 emissions, total energy consumption, contribution of fossil fuels and nuclear energy to energy generation, prices of fossil fuels, energy security (country's dependence on energy imports), the size of a country, and the rate of employment (Marques and Fuinhas 2011a; Marques et al. 2010; Apergis and Payne 2010a, b; Chang et al. 2009; Apergis et al. 2010; Apergis and Payne 2011; Menegaki 2011; Sadorsky 2009; Salim and Rafiq 2011; Maza et al. 2010). All of these studies were performed at the macro-economic level, while taking into consideration the behavior of the RE sector growth in regard to country characteristics and energy-related variables.

Investor protection, which is a major institutional characteristic of a country, is essential for the development of industries that require huge amounts of external investment. Countries with better investor protection exhibit higher economic growth rates. Better investor protection positively affects the growth of industries that depend heavily on external finance and makes the formation of new firms and firms' access to external financing easier (Beck et al. 2000; Beck and Levine 2002). The degree of investor protection depends on the overall financial development of a country, its legal system and investor rights. In addition, the legal system of a country is an important indicator of the degree of the country's financial development. In general, financial markets are better developed when laws provide better protection for external investors and are well-enforced (La Porta et al. 2002). Investor protection insures investors against expropriation of their returns by management or dominant shareholders, or in times of crisis and insolvency, and raises investors' willingness to finance firms (either through debt or equity instruments) (La Porta et al. 1998, 2000). Investor protection can also be seen as an important determinant of the financing-investment decisions of the RE sector. Since better investor protection reduces investors' risk exposure, has a positive effect on industry growth and eases firm' access to external finance, it should play a crucial role in the financing choice of renewable energy companies across countries. Investor protection will indirectly influence RE firms' investment horizons through their external financial policies (Beck et al. 2000; Beck and Levine 2002).

The dataset used for the empirical analysis in this Chapter has a panel setting and consists of 235 publicly listed companies in the alternative energy sector across 23 developing and developed countries in the period 2000–2010. In our analysis, we use a simultaneous equation model where a RE firm's investment is explained by its capital structure. The findings contradict the expected hypothesized relationship. A possible explanation of the contradiction may be that growth opportunities matter for defining the relationship between leverage and investments. The results show that there is a positive relationship between the levels of debt and investments that is significantly stronger for the RE companies with limited growth opportunities, when the target level of debt is measured by several firm and country level variables. However, the consistent positive relationship is weaker for RE firms with higher growth opportunities.

This chapter is organized as follows: Sect. 11.2 presents the theoretical background, including the relationship between investment and financing decisions in general and our expectations in the RE sector. Section 11.3 focuses on the description of the data and the methodology. Section 11.4 presents and discusses the empirical findings of the analysis. Finally, Sect. 11.5 concludes the chapter by including limitations and recommendations for future research.

11.2 Literature Review

The section starts with a review of existing research on the determinants of the RE sector's development. After that the relevant theory on the relationship between investment and financing is presented followed by the investor protection literature. Hypotheses are also specified in this section based on the existing theoretical and empirical evidence.

11.2.1 Determinants of Growth in the Renewable Energy Sector

The two 'oil shocks' in 1973 and 1979 caused by the OPEC group (Oil Producing and Exporting Countries) and a similar situation created in 2002, stressed the need to shift to renewable energy (RE) as a solution to energy security and independence for the industrialized economies (Abbasi et al. 2011; Buchan 2002). In addition, since world energy consumption is the major contributor of CO_2 emissions (about 60 %), its impact on global warming is another important issue one must keep in mind in fighting climate change (Abbasi et al. 2011; IEA 2008).

The recent financial crisis and the economic slowdown caused an 18 % decline in investments in RE sources (IEA 2009). RE companies were hit harder by the crisis. Non-governmental investments in these companies, mainly by private equity and venture capital funds, decreased significantly due to most of them being small in size and having greater risk exposure (Justice 2009). Despite the policies and subsidies that governments have introduced to stimulate a green energy future, the growth of RE sector has not been attractive for private financing. Renewables require huge initial up-front costs, which exposes investors to high political, economic and resource risks, and thus calls for high expected returns on investments in the very long-run (Sonntag-O'Brien and Usher 2004). RE sources are not cost competitive with fossil fuel sources and therefore create low purchasing capacity and less demand, which poses questions as to the sustainability of investing in such companies (Chaurey et al. 2003). The limited historical information on renewable companies' performance, investors' short-term preference for return on their investment, commercially unproven RE technologies, and high due-diligence costs of initial pre-examination of the sustainability of the investment lead investors to prefer more secure investments, such as those in the conventional energy sector (Marques and Fuinhas 2011a; Sonntag-O'Brien and Usher 2004). The RE sector faces these barriers that constraint its ability to attract external financing and raise capital for investment projects and growth (Wiser and Pickle 1998).

The literature has focused on finding drivers that will stimulate the growth of the RE sector. Table 11.1 lists studies on the development of the RE sector by several determinants such as the income level or economic growth of the country, pollutant

Table 11.1 Summary of the literature on the determinants of the renewable energy sector

Studies					Independent variables							
Authors	Research purpose	Sample years	Country sample	Dependent variable	GDP	CO_2	Energy consumption	Fossil fuel sources %	Prices of fossil fuels	Energy security	Employment	Nuclear energy
Marques et al. (2010)	Drivers of RE development	1990–2006	EU countries	RE sources share as a % of total primary energy supply	+	–	+	–	+	+		–
Marques and Fuinhas (2011a)	–‖–	–‖–	24 EU countries	–‖–	+	–	+	–	+	+		–
Chang et al. (2009)	RE development	1997–2006	OECD countries	RE sources share as a % of total primary energy supply	0				+/0			
Apergis and Payne (2010a)	Drivers of RE consumption	1985–2005	20 OECD countries	Total RE electricity net consumption	+						+	
Apergis and Payne (2010b)	Drivers of RE consumption	1992–2007	13 Eurasian countries	Total RE electricity net consumption	+						0	
Apergis et al. (2010)	Casual relationship between CO_2, nuclear energy, RE and GDP	1984–2007	19 countries	Total RE electricity net consumption	+	–			+			–
Menegaki (2011)	Causal relationship between RE consumption and economic growth	1997–2007	27 EU countries	RE sources as a % of gross inland energy consumption	0	+/–					+	

(continued)

Table 11.1 (continued)

Studies					Independent variables							
Authors	Research purpose	Sample years	Country sample	Dependent variable	GDP	CO_2	Energy consumption	Fossil fuel sources %	Prices of fossil fuels	Energy security	Employment	Nuclear energy
Salim and Rafiq (2011)	Determinants of RE consumption	1980–2006	BRIC, Indonesia, Philippines and Turkey	RE consumption demand (composite variable)	+	+/0			–			
Sadorsky (2009)	Empirical model of RE consumption	1980–2005	G7 countries	RE consumption (composite variable)	+	+/–			+/–			

This table shows the existing relationships found in previous research done on the renewable energy sector. A "+" sign denotes a positive relationship between the respective independent variable and the dependent variable; a "–"sign means a negative relationship; and a "0" value means that no significant relationship was found. The independent variables that miss any sign or value have not been included in the respective research emissions, energy security, and the influence of fossil fuels and nuclear energy sources in terms of their prices and contributions to total primary energy supply. Some studies include employment (Apergis and Payne 2010a, b; Menegaki 2011) and total energy consumption (Marques et al. 2010; Marques and Fuinhas 2011a) as explanatory variables to RE growth. The studies summarized in Table 11.1 show that the growth of the RE sector is measured by either total RE electricity net consumption or the contribution of RE sources to total primary energy supply. The table presents an overview of the research purposes of recent articles, independent and dependent variables used for the empirical analysis, and the empirically found relationships between the variables. It is evident that previous research has been conducted mainly at the macroeconomic level by studying RE as a sector, rather than at the-firm level.

None of the prior studies have focused exclusively on analyzing the relationship between RE sector growth and the institutional and the legal environment of the respective countries while keeping in mind the important role institutions and governments play. Earlier research about the political environment and the public policies adopted for the RE sector has a more theoretical approach in discussing the current situation that renewables face. An example is the article by Wang (2006) who discusses the current renewable energy policy developments in Sweden and how they affect the development of the RE sector. Most of the empirical studies that focus on the institutional environment are performed on only one or several particular countries. Carley (2009) explores the effectiveness of state Renewable Portfolio Standard (RPS) policies on the percentage of RE electricity generation by focusing only on the different US states for the time frame of 1998 to 2006.

Few of the empirical studies present country comparative analyses on the policies and the political factors concerning the renewable sector. Marques et al. (2010) introduce an institutional variable (EU/non-EU member) to measure the effect of any kind of governmental policies such as subsidies, grants, compulsory renewable targets (i.e., production quotas, emissions trading), tax mechanisms, feed-in-tariffs, and R&D incentive programs that have been introduced. In their research, they claim that an institutional variable about membership in the European Union can measure the effect of any RE policies on the growth of the RE sector. Since the EU zone has proactively introduced such programs and policies for the promotion of clean energy, the impact of those policies on RE use will be seen in the countries that are part of the zone. However, specific data on the various RE policies by country and for a large span of time is difficult to find, unless there is some institution as the EU to unify the countries. Marques and Fuinhas (2011a) considered the impact of public policies but were unable to include them in their analysis due to a lack of data. In other research, Marques and Fuinhas (2011b), focused primarily on the energy efficiency policies and measures and their effect on the use of RE sources in the total energy supply. They conducted their research on 21 European countries and measured the policy factor by the number of energy efficiency policies and measures introduced in each country. The results for the policy variable were mixed, being insignificant in the first period and significant and positively related to RE use in the second period. However, it has to be noted that a variable measuring the number of energy policies cannot explain anything about the specific effect of a specific policy being introduced.

Since an empirical analysis about the effects of public funds and policies on the RE growth is difficult to perform due to the complexity and variety of mechanisms being introduced, and given the increasing necessity to stimulate private financing in the sector, this chapter takes a different approach. We study the growth of renewable energy at the firm-level and the role of private financing in boosting concern for the future financing policies of those companies. We believe that a perspective on external investor protection will address appropriately the importance of the institutional environment.

11.2.2 Investment and Financing Decisions

The firm's investment decisions are closely tied to its financial policy. Despite Modigliani and Miller's (1958) proposition that financing and investment decisions are independent, there has been a lot of theoretical and empirical research disputing this proposition (Aivazian et al. 2005). Keeping in mind the imperfect nature of debt and capital markets where transaction costs, agency problems, asymmetric information, taxes and costs of financial distress are present, firms take into consideration their financial policies when making investment decisions (McCabe 1979; Aivazian et al. 2005; Dang 2011). For example, informational asymmetries in debt markets may lead to inefficiencies in financial markets that can raise the cost of debt financing to a point where creditors put restrictions on the level of debt financing. In addition, market inefficiencies will limit the ability of financially distressed firms to obtain external financing, which will have affect their investment expenditures by making them largely sensitive to the availability of internal financing (Whited 1992). The high risk nature of investments (economic, political, policy, resource, and technology risks) raise the probability of default of RE firms, and the risk-aversion of lenders will lead them to demand higher interest rates on debt or to restrict debt until the venture reaches a certain level of maturity (Wiser and Pickle 1998; Justice 2009; Whited 1992). The high cost of debt in itself will lead firms to limit their use of debt financing and make them rely more on internal or equity financing for their investments.

In general, research on corporate financing and investment decisions shows a negative relationship between firms' leverage and investment decisions. Two theories can explain the negative relationship: the underinvestment hypothesis (the presence of agency costs between shareholders and bondholders) and the existence or lack of valuable investment opportunities for the firm (Aivazian et al. 2005; Dang 2011). According to the underinvestment hypothesis, firms' overall investment levels will decrease when more debt financing is provided because of the disciplining role that debt has on managerial investment decisions (Aivazian et al. 2005; Dang 2011). When management has large debt commitments (interest and principal payments on the loan) it will have less cash available to allocate across additional and risky investment projects, which in turn will decrease the amount that a firm invests (Aivazian et al. 2005).

Even if valuable investment opportunities exist, highly leveraged companies are less likely to take advantage of those opportunities because of the debt overhang problem, which will lead to a decrease in investments (Aivazian et al. 2005; Ahn et al. 2006). Debt overhang reduces the incentives of management and shareholders to undertake positive net present value investments, because part of the benefits goes to the bondholders (Dang 2011). Therefore, highly levered firms in general will invest less irrespective of the nature of their investment opportunities. In addition, since debt usually is issued for low-risk low-return projects, it will restrain management from investing in too risky projects (Lang et al. 1996).

11.2.3 Investment and Financing in the RE Sector

Governmental funding and the RE policies and mechanisms have been essential sources of financing for the RE companies. Recently, however, private (commercial) external financing has gained greater significance as a financing source for RE investment projects (Wustenhagen and Menichetti 2012). The policies and mechanisms that have been introduced have ensured certain benefits for the RE sector, such as creating new market opportunities, supporting technology development, decreasing RE electricity costs, etc. (Wustenhagen and Menichetti 2012). However, those policies have not sufficed to stimulate more private financing in this sector and to ensure sustainable growth in comparison to the conventional energy sectors. The increasing importance of private financing requires the establishment of new financial mechanisms aimed at attracting external investors by providing long-term stability, adequate returns, and decreased risks to investors (Wiser and Pickle 1998; Sonntag-O'Brien and Usher 2004). The previously developed policies partly neglected the financing needs of RE companies, which resulted in inadequate external financing provided (Wiser and Pickle 1998). It is evident that governmental intervention is a crucial driver for RE growth and development, but enhancement of private external financing is needed for RE firms to realize their investment projects and to grow. External financing is essential for renewables because they are highly capital intensive and face a high degree of up-front costs that require debt or equity funding (Wiser and Pickle 1998).

Private equity and venture capital funding or some kind of quasi equity finance such as mezzanine finance play an important role in the early stage of external financing for RE companies (IEA 2009; Sonntag-O'Brien and Usher 2004). Equity investors undertake high-risk investments when there are large potential returns, because they have the possibility for limitless returns in the form of dividends or an ownership stake in the company (Wiser and Pickle 1998; Justice 2009). Therefore, equity financing is the preferred choice for financing early stage investments and should influence them positively. On the other hand, debt financing is relied on during the operating and the end stage, where operating financing usually comes in the form of corporate debt and interest rate subsidies, and end-user financing is provided in the form of consumer micro-credit and supplier debt (Sonntag-O'Brien and Usher 2004). In addition, debt financing is preferred by high-cost investment projects, such as offshore wind projects, that are generally also more risky. Debt financing is harder to find for such projects and more expensive due to the high risk premiums (IEA 2009). In addition, the financial crisis made it even more difficult and expensive to raise debt, especially for high-risk projects, which impeded and postponed a lot of RE investment projects (Justice 2009; IEA 2009). The riskier the project or investment, the greater the share of equity financing required by creditors to secure the debt issued (Sonntag-O'Brien and Usher 2004; Justice). This suggests that equity financing takes a larger part of RE investment projects and should have a positive and stronger influence on RE firm investment. However, the ability to raise more debt by securing a larger percentage of the investment with equity financing, will also affect the firm's investment levels positively. Therefore, leverage should also significantly influence firm investment and growth; and whether the influence is positive or negative depends on the value of the investment opportunities. On the other hand, the nature of this relationship can be affected in a different way by the institutional, legal and political environment.

11.3 Data and Methodology

The dataset for this chapter has an unbalanced panel setting and consists of 235 renewable energy companies from 23 countries that are observed over a time period of 11 years from 2000 to 2010. Only publicly listed renewable energy companies are studied and therefore company financial data are collected from Datastream, Alternative Energy -Sector. The sampling of the companies has been done by including almost the entire population present on Datastream, by leaving out observations that have very limited time-series data. To avoid the effect of outliers, following previous research, all the financial variables and GDP growth are winsorized at the 5 % level (Aivazian et al. 2005; Dang 2011).

We estimate two linear regression equations to test the relationship between financing and investment decisions and the role that investor protection plays in the financing-investment decision set of RE companies. The two equations will be a financing equation with a dependent variable leverage (representing the financing choice of RE firms) and an investment equation with capital expenditures as the dependent variable (representing the investment levels of RE firms). We use simultaneous equation modeling techniques in a system of two or more regressions that contain two or more interdependent endogenous variables (Hill et al. 2011). The interdependence relationship between financing and investment decisions has been theoretically and empirically proven in previous research, and thus suggests the use of a simultaneous equation model (McCabe 1979). Aivazian et al. (2005) and Dang (2011) have used the 2SLS estimation procedure to deal with the simultaneity relationship between leverage and investment through the use of instrumental variables.

Due to the time invariance of country level variables, in our analysis we use panel OLS and random effect panel data methodologies. The two structural equations of the original specification panel model are as follows:

$$\begin{aligned}DEBTR_{it} = {} & \beta + \beta_1 CR_{it} + \beta_2 SR_{it} + \beta_3 WGI_{it} + \beta_4 PC_{it} + \beta_5 MCAP_{it} + \beta_6 GDP_{it} \\ & + \beta_7 MBR_{it} + \beta_8 SIZE_{it} + \beta_9 TANGI_{it} + \beta_{10} PROFIT_{it} + \beta_{11} D_{eng} \\ & + \beta_{12} D_{fren} + \beta_{13} D_{ger} + \omega_{it}\end{aligned} \tag{11.1}$$

$$CAPEX_{it} = a + a_1 DEBTR_{it} + a_2 MBR_{it} + \alpha_3 DEBTR \times MBR_{it} + \varepsilon_{it} \tag{11.2}$$

Where:

$DEBTR_{it}$ is the debt ratio, a measure of leverage, for company i at time t
$CAPEX_{it}$ is capital expenditures, proxy of investments, for company i at time t
CR_{it} is creditor rights for company i at time t
SR_{it} is shareholder rights for company i at time t
WGI_{it} is the world governance index for company i at time t
PC_{it} is private credit by deposit money banks and other financial institutions to GDP, a measure of banking development, for company i at time t
$MCAP_{it}$ is stock market capitalization to GDP, a measure of capital market development, for company i at time t
GDP_{it} is GDP country growth for company i at time t
$SIZE_{it}$ is company size, measured by logarithm of total assets, for company i at time t
$TANGI_{it}$ is tangibility of assets, measured as the ratio of fixed to total assets, for company i at time t
$PROFIT_{it}$ is company profitability, measured by EBITDA over total assets, for company i at time t
$\mathrm{MBR}_{\mathrm{it}}$ is the market-to-book ratio, measure for growth opportunities, for company i at time t
$DEBTR \times MBR_{it}$ is an interaction term of the two variables for company i at time t
D_{eng}, D_{fren}, D_{ger} are dummy variables for English law, French civil law, and German civil law system respectively
$\varepsilon_{\mathrm{it}}$, ω_{it} are the random sampling errors for company i at time t

We measure a firm's financial policy by its capital structure choice (DEBTR). The extent to which a company is financed either with debt or equity can be measured by different leverage ratios. The leverage ratio that is used in the analysis is the debt ratio, which is defined as total debt (WC03255) over total assets (WC02999). Firm investment is a proxy for firm growth and is measured by the capital expenditures (CAPEX). We measure firm investment as a share of total assets and therefore the formula is: capital expenditures (WC04601) less depreciation and depletion (WC04049) over total assets (WC02999). The *market to book ratio* (MBR) used in this study is measured as the market value of equity times the shares outstanding of the company (WC08001) plus total liabilities (WC03351), divided by the total assets (WC02999). Firm size (SIZE) is measured as the natural logarithm of total assets (WC02999) since the other firm variables are measured mostly as a share of total assets. Tangibility of assets (TANG) is measured as firm's fixed assets to total assets. Tangible assets are defined as Property, Plant and Equipment (WC02501) in Datastream and represents gross property, plant and equipment less accumulated reserves for depreciation, depletion and amortization. Profitability (PROFIT) is measured by Earnings Before Interest, Taxes and Depreciation (EBITDA) (WC18198) divided by total assets (WC02999) (Rajan and Zingales 1995). Annual GDP percentage growth in real $ US prices (GDP) is used as a measure of economic development and data is obtained from the World Bank, World Development Indicators and Global Development Finance.

The creditors' rights index (CR) is the Djankov et al. (2007) revised index of creditor rights that was initially developed by La Porta et al. (1998). A higher value of the index suggests well-protected creditors' rights. The shareholder rights (SR) index is based on the revised Djankov et al. (2008) anti-self-dealing index based on the legal rules for 2003 for 72 countries. The higher the value of the index, the better protected are the rights of shareholders. The World Governance Index (WGI) is an aggregate measure of six governance indicators constructed by Kaufmann et al. (2009, 2010). PC is the measure of Private Credit by Deposit Money Banks and Other Financial Institutions to GDP, which is collected from the World Bank Financial Structure Database until the year 2009 based on the research by Beck and Demirguc-Kunt (2009). Private credit isolates credit issued to the private sector from credit issued to governments, government agencies, and public enterprises and excludes central bank debt (Levine et al. 2000). This ratio is a good proxy for the level of banking development and is used in several studies as a determinant of capital structure (Rajan and Zingales 1995; Alves and Ferreira 2011; Booth et al. 2001). The development and size of the stock markets is measured by stock market capitalization as a share of GDP (MCAP), which equals the value of listed shares over GDP. The data is taken from the World Bank Financial Structure Database from the study by Beck and Demirguc-Kunt (2009). The stock market capitalization ratio is used as a determinant of capital structure and preference for equity financing in the studies by Rajan and Zingales (1995), Jong et al. (2008), Cheng and Shiu (2007), Booth et al. (2001), Agarwal and Mohtadi (2004). The countries' legal origins identified by La Porta et al. (1998) are represented with dummy variables using the indicator coding approach. The Scandinavian civil law countries will be used as the reference category for this study and the dummy variables *eng, fren* and *ger* are included.

Table 11.2 reports the countries and number of renewable energy companies per country studied in this chapter, and gives an overview of the cross-country summary statistics of country-level variables and the most important firm-specific variables. The sample is represented well by both developed and developing countries. The Unites States, The United Kingdom, Canada, France, Germany, Japan, Sweden, Denmark, and Norway belong to the well-developed economies. On the other hand, India, China, Brazil, Singapore, and Thailand represent some of the fastest developing economies. The English common law and German civil law countries are represented by the largest number of companies in the sample,

Table 11.2 Cross-country summary statistics

Countries	N	Legal origin	*CR*	*SR*	*WGI*	*PR*	*MCAP*	*GDPG*
Australia	15	English	3	4	1.169	1.019	1.260	3.136
Canada	17	English	1	4	1.631	1.494	1.275	2.193
Honk Kong, China	7	English	4	5	1.350	1.411	4.353	4.443
India	5	English	2	5	−0.235	0.368	0.868	7.255
Israel	2	English	3	4	0.554	0.847	0.957	3.700
New Zealand	1	English	4	4	1.678	1.248	0.359	2.427
Singapore	3	English	3	5	0.667	1.110	1.875	5.497
Thailand	1	English	2	4	−0.054	0.910	0.586	4.402
United Kingdom	13	English	4	5	1.474	1.543	1.420	2.036
United States	95	English	1	3	1.303	1.885	1.398	1.849
English common law	159		2.7	4.3	0.95	1.18	1.44	3.69
Brazil	2	French	1	5	0.020	0.374	0.644	3.669
France	2	French	0	3.5	1.228	0.931	0.931	1.376
Italy	1	French	2	2	0.663	0.873	0.493	0.850
Spain	3	French	2	5	1.057	1.354	0.947	2.381
French civil law	8		1.25	3.88	0.74	0.88	0.75	2.07
China	10	German	2	1	−0.538	N/A	0.510	8.964
Germany	31	German	3	3.5	1.513	1.103	0.547	1.300
Japan	3	German	2	4.5	1.134	1.145	0.850	1.194
Korea, Rep.	4	German	3	4.5	1.746	1.151	0.764	4.550
Switzerland	1	German	1	3	1.747	1.625	2.712	1.851
Taiwan, China	14	German	2	3	0.846	N/A	1.426	3.936
German civil law	63		2.17	3.25	1.07	1.26	1.14	3.63
Denmark	1	Scandinavian	3	4	1.852	1.632	0.696	1.074
Norway	1	Scandinavian	2	3.5	1.467	0.958	0.626	1.675
Sweden	3	Scandinavian	1	3.5	1.761	1.021	1.196	2.458
Scandinavian civil law	5		2	3.67	1.69	1.20	0.84	1.74
Total obs.	235		2,585	2,585	2,585	2,107	2,330	2,584

This table presents cross-country summary and descriptive statistics of country-level variables. The total number of companies per country is shown as well as the total observations for each variable. The table presents mean values of the time-variant variables for each of the 23 countries and average per legal origin for the period 2000–2010

respectively 159 and 63. The United States and Germany are the two countries that have the largest number of companies included in the sample: 95 and 31. The French and Scandinavian civil law countries have limited number of firm observations, 8 and 5 respectively. New Zealand, Thailand, Italy, Switzerland, Denmark and Norway are represented by only one company. Therefore, conclusions about the financing-investment behavior of RE companies in French and Scandinavian civil law regimes and those countries may not be generalizable. Due to the limited number of company observations per country, the descriptive results are presented and analyzed in respect to group of countries belonging to the same legal system.

Table 11.3 Descriptive statistics of institutional and financial variables

	Mean	Median	Maximum	Minimum	Std. Dev.	Observations
DEBTR	0.247	0.139	1.000	0.000	0.291	1,677
CAPEX	0.061	0.015	0.362	−0.052	0.107	1,567
MBR	4.251	1.904	20.000	0.690	5.466	1,335
LOGTA	10.099	10.353	14.411	4.488	2.631	1,662
PROFIT	−24.29 %	−4.11 %	17.53 %	−174.90 %	0.496	1,394
TANGI	0.238	0.166	0.793	0.000	0.234	1,646

This table presents the descriptive statistics of the firm-level variables. All the financial variables are winsorized at 5 and 95 % levels

Table 11.3 presents the descriptive statistics of the two dependent (endogenous) variables, and the independent firm financial variables included in the first and second stage regressions. The dependent variables DEBTR and CAPEX have a relatively small variation around its mean. The CAPEX ratio variable shows considerably low mean and median values, which suggest that RE companies are not undertaking high investments as a percentage of their total assets. A negative profitability ratio means that the company is not allocating its capital efficiently and is being into a financial distress. Companies with insufficient internal finance should be more levered according to the pecking order theory, because they choose debt financing first rather than equity financing (Alves and Ferreira 2011; Booth et al. 2001). Given the high negative profitability ratios of RE companies (mean: −24.3 %), which increases their probability of default significantly, a mean leverage ratio of 25 % may seem too risky and costly.

11.4 Results and Discussion

11.4.1 Leverage Regressions (First Step)

Table 11.4 provides results from the regressions on leverage using the institutional country-level and financial firm-specific variables as independent variables. The Intercept is positive but insignificant for all regressions, which indicates that there are no significant differences in the relationship between Scandinavian civil law countries and RE companies' leverage levels with the rest of the legal systems. The coefficients of the English legal system (*eng*) dummy variable are negative, confirming the expectation that English law countries use less debt financing. However, the coefficients for *eng* are insignificant for all regressions and thus no significant proof is found that common law countries use less debt financing than Scandinavian civil law countries. The shareholders' rights index is negatively related to leverage, as expected from theory, however its coefficient is insignificant. The creditors' rights index is negatively significantly related to leverage. The RE sector is characterized by R&D and technological innovation investments. For such companies and type of investments, stronger creditor rights may reduce debt

Table 11.4 Leverage regression results (first step)

	Pooled		Random	
	(1)	(2)	(1)	(2)
Intercept	0.144	0.098	0.206	0.274
	(0.130)	(0.391)	(0.147)	(0.121)
CR	−0.028***		−0.028**	
	(0.001)		(0.049)	
SR		−0.012		−0.032
		(0.377)		(0.159)
WGI	−0.078***	−0.107***	−0.095***	−0.105***
	(0.000)	(0.000)	(0.001)	(0.001)
PR		0.084***		0.005
		(0.004)		(0.865)
MCAP	0.018*		0.014	
	(0.089)		(0.287)	
GDPG	−0.004	0.000	−0.006**	−0.006**
	(0.187)	(0.998)	(0.031)	(0.033)
SIZE	0.006	0.005	0.004	0.006
	(0.206)	(0.370)	(0.510)	(0.365)
MBR	0.005**	0.005**	0.005**	0.005**
	(0.019)	(0.040)	(0.019)	(0.011)
PROFIT	−0.113***	−0.110***	−0.111***	−0.110***
	(0.000)	(0.000)	(0.000)	(0.000)
TANG	0.296***	0.293***	0.284***	0.282***
	(0.000)	(0.000)	(0.000)	(0.000)
ENG	0.000	−0.020	−0.001	0.004
	(0.997)	(0.754)	(0.991)	(0.968)
FREN	0.116*	0.131*	0.046	0.071
	(0.087)	(0.075)	(0.707)	(0.581)
GER	0.097*	0.093	0.081	0.054
	(0.097)	(0.148)	(0.439)	(0.623)
Total observations (cross-sections)	935 (220)	881 (205)	935 (220)	881 (205)
Hausman test (p-value)			(0.950)	(0.629)
Adj. R-square	0.155	0.156	0.135	0.134

The table provides the first step results of the two-stage least squares estimation (instrumental variable approach) of the leverage equation. The empirical results of the effects of country-level and firm-level variables on leverage are based on panel OLS and random effect techniques. P-values are provided in parentheses below the coefficient values. ***Indicates significance at 1 %, **Indicates significance at 5 %, and *Indicates significance at 10 %

financing because of the greater risk and uncertainty that such investments hold and the higher possibility of such firms to face financial distress costs (Seifert and Gonenc 2011; Acharya et al. 2011). The WGI index is significantly and negatively related to firm leverage in all regression models, which is consistent with the developed hypothesis. In countries where legal enforcement is better exercised (i.e., the WGI index is stronger), companies tend to use less debt financing (Jong et al. 2008; Alves and Ferreira 2011). There is support for the bank-based view that it stimulates more debt financing since private credit is significantly and positively related to firm leverage, which indicates that a better developed banking system stimulates more debt supply and consequently results in higher firm debt financing (Alves and Ferreira 2011; Booth et al. 2001; Jong et al. 2008; Cheng and Shiu 2007). However, no strong support is found for the market-based view claiming that stock market development negatively influences firm leverage and thus leads to more equity financing (Cheng and Shiu 2007; Agarwal and Mohtadi 2004; Levine 2002; Alves and Ferreira 2011; Booth et al. 2001). GDP growth is sometimes significant and shows mixed results as to the nature of the relationship with leverage.

From the firm-level variables, market-to-book ratio, profitability and tangibility are highly significant in the relationship with leverage for RE companies. A positive relationship is found between the market-to-book ratio and firm leverage, which supports the argument that valuable investment opportunities add value to the firm and thus increase its debt capacity. Profitability and tangibility are both highly significantly related to leverage and the expected signs are found in all the regression models. Highly profitable companies make less use of debt financing since they prefer to finance their investments internally rather than externally according to the pecking order theory. Companies with a higher ratio of tangible assets to total assets make greater use of debt financing since their tangible assets are used as collateral when creditors provide loans (Jong et al. 2008; Booth et al. 2001).

11.4.2 Investment Regressions (Second Step)

The second step regressions include the predicted value of the debt ratio, which is obtained from the first step regressions. Equation 11.1 tests the effect of leverage on the investment itself, and Equation 11.2 tests the combined effect of growth opportunities and leverage on investment by adding the interaction term between leverage and growth opportunities. The results in Table 11.5 show that the relationship between leverage and investment is significantly positive. This suggests that the explanatory variables in the second-stage regression models are good predictors of firm's capital expenditures, and the instruments used are also strong indirect predictors of investment through the endogenous explanatory variable leverage. The positive relationship between investment and leverage for the RE companies confirms the fact that the sector needs external financing in the form of debt to be able to increase its investments. However, incorporating higher growth opportunities into this relationship changes the direction. If a RE company presents higher growth opportunities reflected by high market to book ratio, this creates a debt overhang problem and causes shareholders to decide not to invest in some profitable investments.

Table 11.5 Investment regression (second step)

	Pooled		Random	
	(1)	(2)	(1)	(2)
Intercept	−0.043***	−0.126***	−0.032***	−0.104***
	(0.004)	(0.000)	(0.072)	(0.000)
DEBTR	0.591***	0.854***	0.509***	0.754***
	(0.000)	(0.000)	(0.000)	(0.000)
MBR	−0.009***	0.015***	−0.007***	0.013***
	(0.000)	(0.000)	(0.000)	(0.000)
*DEBTR*MBR*		−0.058***		−0.048***
		(0.000)		(0.000)
Total obs. (cross-sections)	990 (213)	990 (213)	990 (213)	990 (213)
Hausman test (p-value)			(0.116)	(0.306)
Adj. R-square[a]	−2.331	−2.055	−1.629	−1.374

The table provides the second step of the two-stage least squares estimation (instrumental variable approach) of the investment equation. The empirical results of the effects of country-level and firm-level variables on leverage are based on panel OLS and random effect techniques. P-values are provided in parentheses below the coefficient values. ***Indicates significance at 1 %

[a]The Goodness of fit measure (R-squared) is computed in 2SLS estimations by using the standard formula: $R^2 = 1 - SSR/SST$, where SSR is the sum of squared residuals and SST is the total sum of squares. Negative adjusted R-squares are negative because SSR is larger than SST. Therefore, as it happens most of the time, the R-square measure is irrelevant to interpret for 2SLS estimations (Wooldridge 2002; Hill et al. 2011; Brooks 2008)

Conclusions

Investment in the RE sector is the way to achieve sustainable economic recovery from the financial crisis, ensure a country's energy security, fight climate change and environmental pollution, and create permanent employment gains. Apart from public support in the form of governmental grants and subsidies, and energy policies and mechanisms, the growth of the RE sector depends largely on private external financing. In order to stimulate investment and growth in the sector on a commercial and large scale, private external financing should be supported. Therefore, the purpose of this chapter was to analyze the corporate financing-investment decision behavior of the RE companies and to support the idea that financing and investment decisions are related and thus simultaneously taken. The financing-investment decision set of RE companies is studied in the context of a country's institutional factors representing the investor protection environment. A firm's financial policy is determined by firm-level and country institutional factors, which play a crucial role in defining whether a firm finances its investments with debt or equity. An investor protection perspective is taken when choosing the institutional factors, since the type of external financing obtained by companies is largely driven by external investors' willingness to supply it. The analysis uses a sample of 235 publicly listed renewable energy companies from 23 countries, observed over the time period from 2000 until 2010.

The results from the first-stage regression on leverage are mostly consistent with previous research on the determinants of capital structure. We find strong significant results for creditor rights, WGI index, private credit and all the firm-level variables apart from SIZE. In the second-stage regression on investment, we find highly significant but positive relationship between leverage and firm investment. This result is inconsistent with overall results found in the literature for a significant negative relationship between financing and investment decision for firms from different industries. The positive relationship in the RE sector can be explained with the argument that RE companies need to use debt to finance their investments. However, when RE companies have higher growth opportunities, they prefer to use less debt to finance their investments.

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Prospective Costs for the Aviation Sector of the Emissions Trading Scheme 12

Gerard Mooney, Cal Muckley, and Don Bredin

Abstract

This chapter analyses the cost impact to the aviation sector of the European Union Emissions Trading Scheme (EU ETS) being extended to include the sector. To motivate our cost impact simulation work, we initially study ultra-high frequency data utilising the December 2012 European Union Allowance (EUA) futures contract. We find evidence indicative of EU ETS market efficiency. Hence, we inform our simulation specification using information set related to fundamental price determinants. We find a minimal cost impact of an EU ETS extension to the industry sector of almost 9 billion Euros for the period 2012–2020. Such a material cost accrues from a nominal price of 10 Euro per tonne of CO_2 emissions. This chapter contributes to emerging research on the cost impact of the EU ETS to the aviation sector.

12.1 Introduction

Worldwide aviation emissions have grown by 98 % between 1990 and 2006, and are forecast to increase by 667 % from 2006 to 2050 Standard and Poor's (2011).[1] At present, the aviation sector accounts for 4 % of total European carbon dioxide (CO_2) emissions (International Centre for Trade and Sustainable Development 2011). As a result, there are compelling environmental reasons for an EU extension

The views expressed here are those of the authors and do not in any way represent the views of the institutions to which they are affiliated.

[1] These projections assume a constant level of technological mitigation of emissions, see Air Transport Action Group 2010, Farries and Eyers (2008) and Lee et al. (2001). Lee et al. (2001), found 57 % of energy reduction came from engine efficiency, while aerodynamics efficiency

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of the Emissions Trading Scheme (EU ETS) to the aviation sector.[2] Including aviation in the EU ETS is forecast to save around 176 million tonnes of CO_2 emissions by 2015 (European Commission).[3] In this study we examine, the cost impact to the sector of any such initiative. Unlike prior work, we combine a simulation procedure to relate fundamental price determinants to the estimated cost of an extension of the EU ETS to the sector.

There is a substantial body of work relating to the maturity and efficiency of the EU ETS market: Bredin et al. (2013), Bredin and Muckley (2011), Koch (2011), Joyeux and Milunovich (2010), Mizrach (2012), Bredin et al. (2012), and Paolella and Taschini (2008). In particular, Bredin and Muckley (2011) identify the emergence of a long-run equilibrium in the EU ETS, and how a rising level of efficiency is evident. Koch (2011) shows rising co-movements between carbon and financial markets, providing further evidence of a maturing EU ETS market, consistent with an emergent sensitivity to common risk factors. Joyeux and Milunovich (2010) and Mizrach (2012) also indicate a gradual improvement in the EU ETS market efficiency. More recently, Bredin et al. (2013) reveal a high level of correlation between the European Union Allowance (EUA) spot and futures markets; indicative of an emerging stability within the market in respect to convenience yields. Recent related microstructure style studies include, for example, Conrad et al. (2012). Conrad et al. (2012) show that macroeconomic and allocation plan announcements impact EUA futures returns within several minutes of announcement. In this chapter, we *first* complement these findings

accounted for 22 %. Farries and Eyers (2008) detail historical performance developments, and forecast fuel savings from engine and airframe improvements of 20–30 % and 20 % respectively, by 2025. Air Transport Action Group 2010 present updated material, accounting for the new European Air Traffic Management (ATM) initiatives and find similar conclusions. The rate of emissions reductions to date, however, is largely independent of the EU ETS principally due to weak anticipated EUA prices Zhang and Wei (2010).

[2] The scheme has been instigated since 2005 as part of the EU agreement to cut worldwide emissions of carbon dioxide (CO_2) within the Kyoto Protocol. The scheme issues a restricted amount of emission allowances to firms on an annual basis. At the end of the year firms must hold the required amount of emission permits to meet their emissions of CO_2 over the previous year. The ETS allows firms to trade the amount of emission permits that they hold and as a result has applied a market value to this externality. In the EU ETS context the first phase of trading was 2005–2007 and the second one, which coincides with the first compliance period of the Kyoto Protocol, is 2008–2012. The third European trading phase has commenced in 2013. Now a single, EU-wide cap on emissions applies in place of the previous system of 27 national caps. In 2013 more than 40 % of allowances will be auctioned, and this share will rise progressively each year. For commercial airlines, the system covers CO2 emissions from flights within and between countries participating in the EU ETS (except Croatia, until 2014). The scheme's application to non ETS countries was deferred in 2012 to allow time for agreement on a global framework for tackling aviation missions to be reached in autumn 2013.

[3] To date, regulation allows airlines to use European Union Allowances (EUA) or European Union Aviation Allowances (EUAA). EUAs are used by both land based industries and airlines, while EUAAs can only be used by airlines. In Sect. 12.3, we show that the EUAA futures price changes are highly correlated with those of EUA futures price changes.

to study ultra-high frequency intra-day patterns. According to Engle and Russell (2004), well developed stock markets exhibit an intra-day U-shape for trade volume, and indeed we show that December 2012 EUA futures exhibit the same pattern. In addition, we show very low durations (many sub one second), and substantial trading volumes, which reflect improved liquidity in the EU ETS market over time. Hence, taking the literature findings and our own intraday illustrative work together we provide evidence of a mature market which is related to EUA price driver fundamentals.

There are extant studies which estimate cost impact projections for the aviation sector of CO_2 emissions including York Aviation (2008), Bloomberg New Energy Finance (2011), OAG (2012) and Carbon Trust (2009). In 2008, York Aviation predicted costs of between 40 and 65 billion Euro for the airline industry; assuming prices of between 30 and 50 Euro per tonne of CO_2 emissions respectively for 2012–2020. Carbon Trust (2009) adopted a price of 25 Euro per tonne, with a resultant overall cost range of 23–35 billion Euros, for the period 2012–2020. Regarding airline profitability, the Carbon Trust (2009) suggested that the more efficient airlines, could achieve profits of 20–40 % higher than their inefficient counterparts; based on carbon prices of 25–30 Euros per tonne. Bloomberg New Energy Finance (2011) projected 8–32 billion Euro for the same period. Notably, these studies project consistently high costs, albeit with a downward trend. However, this prior work has not been formulated using a simulation function, and this leads to the second key contribution of our study.

Drawing on the empirical model reported by Bredin and Muckley (2011), we conduct a number of simulations associated with the likely cost of an EU ETS extension to the aviation sector. This constitutes the basis of our cost analysis, which has produced results consistent with the lower projections of Carbon Trust (2009), and York Aviation (2008). We find a minimal cost impact of the EU ETS extension to the industry sector of almost 9 billion Euros for the period 2012–2020. Such a material cost accrues from a nominal price of 10 Euro per tonne of CO_2 emissions. In fact, based on our price simulations, a price range of 17 Euro to 51 Euro per tonne of CO_2 emissions is anticipated by 2020. This price range suggests that the cost impact of extension of the EU ETS to the aviation sector is substantial, and cannot necessarily be absorbed by the industry. These expenses are likely to be passed through to the customer and result in a mitigation of emissions from the sector.[4]

The remainder of this chapter is organised as follows. In Sect. 12.2, the background to extending EU ETS to the aviation sector is presented. In Sect. 12.3, the micro-structure level findings are presented with regard to the EU ETS market. Section 12.4 provides CO_2 emission price simulations for 2012–2020, and utilises

[4] To elaborate, embedded in European Commission forecasts, with respect to emissions abatements, is an expectation that competition in the sector in combination with improved clean technologies will incentivize a reduction in emissions.

scenario analysis to estimate the cost to the aviation sector. Section 12.5 concludes with a brief summary.

12.2 Aviation Sector and EU ETS

This section describes the EU ETS Aviation rules, benchmark cap calculations, international community debate, and conjectured policy impact of excess and fewer allowances on the EUA and EUAA markets.

12.2.1 Background Rules to the EU ETS Extension

The proposed extension of the EU ETS to the aviation sector can be described as follows. It is mandatory for all flights landing or taking off from the EU to report their emissions and procure allowances for them (European Commission 2013). EU regulation indicates airlines may submit either EUAs or EUAAs to meet their CO_2 emission obligations. These allowances must be obtained by each year end and must be reported on by April the following year. Collectively, they can consist of free allowances assigned by the EU, allowances bought from the EU at auction, or they can be those purchased on the open market. Importantly, if airlines do not submit allowances in April for the previous year's emissions, a *penalty*, currently set at 100 Euro per tonne CO_2, will be levied on top of the required allowances. Failure to comply with penalties could result in a ban on that airline operating within the EU.

12.2.2 Benchmark

The benchmark cap is central to pricing, as it remains the reference point for the CO_2 emissions supply demand equation. Table 12.1 presents the sequence of benchmark calculations. It shows that the cap is calculated, by the European Union, by taking an average for the 2004–2006 emissions. This cap was revised downwards in 2009 and again reduced in 2011. In 2011, an extra allowance of 1.6 % was also added for Auxiliary Power Units (APUs).[5] In addition, in 2011, a cap was introduced for three countries outside the EU who wished to participate in the scheme: Iceland, Lichtenstein and Norway.

For 2012, the EU will provide 85 % of the allowances free of charge to airlines who have submitted emission data for 2011 and auction the remaining 15 % of

[5] The APUs provide power for purposes other than propulsion, such as engine ignition and electrics.

Table 12.1 Benchmark emissions calculations

Year	Tonnes emitted
2004	206,283,339
2005	217,844,372
2006	225,699,071
Average	216,608,927
2009 Recalculation	216,588,594
2011 Revised calculation	216,018,858
2011 Flight CO_2	216,018,858
2011 APU CO_2	3,457,485
Total CO_2	219,476,343
EU 27	219,476,343
EEA-EFTA 3	1,943,935
Total for EEA 30	221,420,278
97 % for 2012	214,777,670
95 % for 2013–2020	210,349,264

Historical benchmark calculation is based on average CO_2 emissions between 2004 and 2006, with extra allowances added for Auxiliary Power Unit CO_2 and three non-EU countries

allowances. For each subsequent year, from 2013 to 2020, the EU will provide 82 % of the allowances free of charge; reserve 3 % for new entrants or rapidly growing airlines, and auction the remaining 15 %. Should an airline require more allowances over its free allocation, they will have to purchase those at auction or on the open market. In 2012, airlines may submit Certified Emission Reductions (CERs), for up to 15 % of their allowance requirements. In November 2012, the EU decided to postpone for 1 year EU ETS charges on flights entering and leaving the EU territory (Eurocontrol 2012). All intra-EU flights still require EUAs to offset emissions.

12.2.3 International Debate

Notwithstanding the International Civil Aviation Organization's (ICAO) public endorsement of emissions trading as a method of global emission reduction it has failed to implement a global framework for emissions reduction.[6] In 2010, it adopted a resolution to develop a feasibility study for review in 2013 and proposed a voluntary commitment protocol to improve worldwide fuel efficiency by 2 % annually up to 2020.[7] Hence, there is compelling evidence that the international aviation sector acknowledges the need to reduce global emissions, and that; furthermore, a global solution is required, due to the border-less nature of air travel.

[6] The ICAO is a UN agency with responsibility for aviation. Its resolution 35–5 (2004) endorses emissions trading in principle.

[7] Resolutions 37th ICAO Assembly 2010.

However, the ICAO initiatives were considered inadequate by the EU, which has proceeded with an EU ETS extension proposed for the aviation sector. Non-EU carriers objected to being included in the EU ETS as part of their flight emissions occurred outside of the EU but a US initiated lawsuit brought against the EU ETS in 2011 was rejected by the EU Advocate General. A possible solution to that objection might have been to restrict EU ETS to intra-EU flights but this would have reduced it to just 20 % of the EU-25 aviation emissions (Frontier Economics 2006).[8]

Enshrined in the Kyoto Protocol is the principle that developed counties have the heavier burden for mitigating greenhouse gases. This is known as the Common But Differentiated Responsibility (CBDR). The Kyoto Protocol was adopted in 1997 and came into force in 2005. However, the EU ETS treats all carriers equally, potentially disadvantaging the faster growing airlines from developing countries. To compensate, the EU Commission has reserved allowances of 3 % annually between 2013 and 2020 for new entrants and fast growing airlines. A further concession to developing countries is the exclusion of low volume airlines with total annual emissions of less than 25,000 tonnes of CO_2 emissions. Despite these concessions some countries still object to the EU ETS as an infringement of the CBDR principle.

In September 2011, a total of 26 countries including the USA, Russia, India, China, Japan, South Korea and Mexico signed a declaration at the ICAO meeting in New Delhi opposing the EUs EU ETS for the aviation sector. Other countries, including Australia, Canada and New Zealand were not signatories. In February 2012, the 26 EU ETS opponents, agreed to cancel further joint action, leaving each government to decide its own response. Of note, Australia has announced it is in negotiation with the EU to join the EU ETS no later than 2018 while the United States has approved (but not implemented) legislation blocking its carriers participation in the EU ETS.

12.2.4 Policy Impact on EUA/EUAA Price

Since its introduction in 2005, the EUA market has suffered significant turbulence, but there is evidence to suggest that the market has matured (Bredin and Muckley 2011). In contrast, the EUAA market remains scientifically untested. A possible glut of EUAAs alongside reduced consumer flight demand could have a large negative impact on its price, with an unpredictable EUAA floor price. Significantly, the EUAA price will not exceed the EUA price as aviation operators would just revert to EUAs instead. However, if a shortage of EUAAs occurs, this could result in a price rise for EUAs.

[8] The EU as of 1-May-2004 (consisting of 25 countries).

To date, there have been considerable discussions regarding a carbon floor price, to secure sufficient price pressure for emissions reduction. Australia has a fixed carbon price (AUS $23 per tonne of CO_2 emission) for 2012–2015, which will be followed by a trading scheme linked to the EU ETS (with no floor price). The UK government has proposed a current floor price of 16 pounds sterling per tonne, rising to 30 pounds sterling per tonne by 2020. This would be administered in the form of a carbon tax set between the EU ETS price and the designated floor price. Recently Bloomberg's New Energy Forum recommended a current price of 45 Euro per tonne of CO_2 emissions to incentivise carbon reduction. Even though the notion of floor prices is not new the EU has resisted attempts to regulate the market. Arguments against a floor price include counterproductive market interference; higher costs of achieving the target and further policy uncertainty (see Grüll and Taschini 2011).

12.3 Data and Methodology

This section presents and analyses the EUA and EUAA data to provide insight into the market dynamics and concludes with a description of the adopted price simulation methodology.

12.3.1 Emissions Trading

The EUAA is the instrument of choice for analysing the market dynamics but while trading has already commenced in this instrument activity has been extremely limited. This indicates EUAAs lack of susceptibility to meaningful analysis. Subsequently, it will be shown that EUAs provide a legitimate proxy with respect to analyses, even though they are different allowances.[9]

As an indication of the lack of trading activity from February 27 to December 12 2012, just 15 EUAA trades have transacted on the Intercontinental Exchange.[10] The trade details are shown in Table 12.2.

Figure 12.1 displays the closing 'end of day' prices for the December 2012 contracts and clearly illustrates that EUAs and EUAAs consistently trade in a similar fashion. As a result, we turn to study EUAs subsequently in this chapter. Daily prices are computed using quotes and guidance by market participants.[11]

[9] EUAs are used by both stationary emitters and airlines while EUAAs can only be used by airlines.

[10] Source: Bloomberg Terminal (Accessed 04-Jan-2013).

[11] The pairwise correlation coefficient between EUAs and EUAAs is 0.98.

Table 12.2 EUAA trades on ICE exchange

Date	Size	Price
27-Feb-2012	1	9.40
27-Feb-2012	10	9.46
29-Feb-2012	10	8.45
26-Mar-2012	10	6.40
28-Mar-2012	10	6.85
30-Mar-2012	10	6.60
11-Apr-2012	10	6.40
07-Sep-2012	10	7.98
13-Sep-2012	10	7.35
25-Sep-2012	50	7.10
10-Oct-2012	10	7.36
08-Nov-2012	19	7.45
12-Nov-2012	10	8.25
15-Nov-2012	20	5.75
12-Dec-2012	20	5.90

12.3.2 EUA Data Analysis

The Table 12.3 reports a series of summary statistics for the December 2012 contract returns including measures of central tendency, variability, higher moments, and a test for normality. The December 2012 contract dataset is composed of the trades which occurred from 3rd January 2012 to 17th December 2012.

From the measures of central tendency, these results indicate that the EUA December expiration contract returns are close to zero and the range is quite narrow for the entire time period studied.

The *skewness* of the data set is only slightly negative, which is not surprising given the equivalence of the mean and median. The EUA *kurtosis* value is high, indicating leptokurtosis (fatter tails), again a feature of commodity and financial returns. The value of 41.221 for kurtosis is also highly significant, indicating a concentration of data in the tails of the distribution. According to Engle and Russell (2004) high kurtosis is typical in high frequency data.

A test of normality (Bera and Jarque 1981) was performed to determine if the EUA returns are normally distributed, and the results show a rejection of this null hypothesis at the 5 % significance level. We also examined the extent of serial dependence in EUA returns. The results of both the autocorrelation and partial autocorrelation functions are reported in Fig. 12.2.

A Box-Pierce test was used to test simultaneously for autocorrelations at a range of lag lengths. The results, reported in Table 12.3, indicate that at the 1 % significance level the Q-statistic is significant at all lags. There is no evidence of serial correlation beyond the third lag, when looking at the correlations individually. Hence, there would appear to be dependence in the data and according to Engle and Russell (2004) this is typical in high frequency data with the first negative

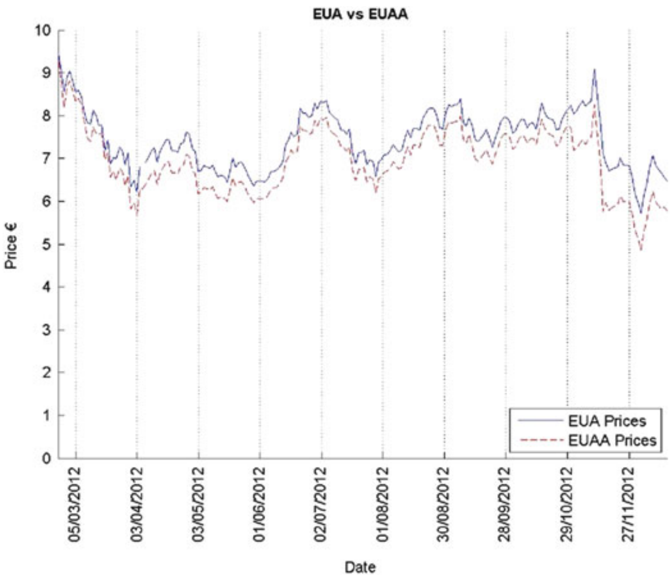

Fig. 12.1 EUAs and EUAAs

autocorrelation being attributed to the bid-ask bounce. It is possible that an additional factor leading to price change dependence is large investors breaking up large orders, to gain a better price, but at the same time creating a sequence of transactions, that impact the price consistently in the same direction.

12.3.3 Duration Analysis

Firstly, we examined the trading duration for the full 12 month period, between January and December 2012 (Fig. 12.3 left panel). Trade duration is defined as the elapsed time in seconds, between two consecutive trades and zero duration is ascribed to transactions which take place within the same second. For simplicity, trades with zero duration have been deleted. Trade durations by the hour for the same period are shown in the centre panel of Fig. 12.3. The daily trading period is between 07:00 and 17:00 GMT. The hump shape is consistent with the duration behaviour in standard asset classes, with a relatively large amount of trading activity in the morning which eases off at about lunchtime and there is a growth in volumes traded again in the afternoon.

As is standard in the high frequency literature, the data is adjusted to take account of the above highlighted seasonality. Dacorogna et al. (2001) interpret

Table 12.3 2012 EUA data analysis

	December 2012 contract
Time period	
From	03-Jan-12
To	17-Dec-12
No. of observations	301,161
Central tendency	
Mean	0.000
Median	0.000
Mode	0.000
Variability	
Range	0.061
Std dev	0.001
Var	0.000
Higher moments	
Skewness	−0.031
Kurtosis	41.221
Normality test	
P value	0.001
JB stat	18,330,915
5 % significance	5.991
Box pierce Q stat	
Lag 1 P = 0.01 (6.64)	3,703.00
Lag 2 P = 0.01 (9.21)	3,790.70
Lag 3 P = 0.01 (11.35)	3,802.27
Lag 4 P = 0.01 (13.28)	3,802.39
Lag 10 P = 0.01 (23.21)	3,822.96
Lag 20 P = 0.01 (37.57)	3,852.64

reduced frictions and increased trading volumes as improvements in market efficiency and liquidity.

12.3.4 Market Micro-Structure

Order Timing: Fig. 12.4 exhibits the volume of hourly trades.[12] Trades maintain a steady rate up to lunchtime (11:00–13:00 h), when the volume drops as expected. After lunchtime trade volumes pick up immediately and then surge between 16:00

[12] Nearly 40 % of orders were placed for a quantity of 1 (a 1,000 tonne contract), with 68 % comprising of combined order sizes of 1, 2, 5 and 10. At the other end of the scale, there were 75 orders for a quantity of 200 or more. The presence of the small trades indicates individual or small investors; while larger volumes are associated with larger investors (Barber et al. 2006).

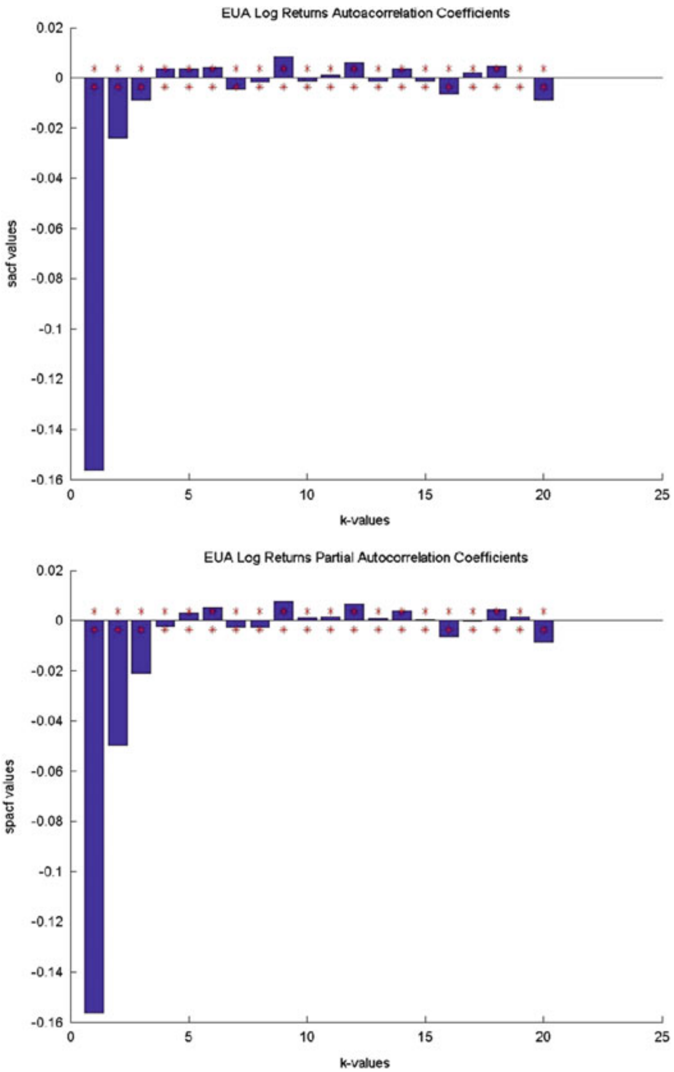

Fig. 12.2 Auto-correlation and partial auto-correlation

and 17:00, the final hour of trading. This likely demonstrates substantial day trading, as traders exit their positions, before close of business.

12.3.5 Price Simulation Methodology

The EUA price simulation is based on recent work by Bredin and Muckley (2011). Six variables encompassing energy prices, economic activity and temperature

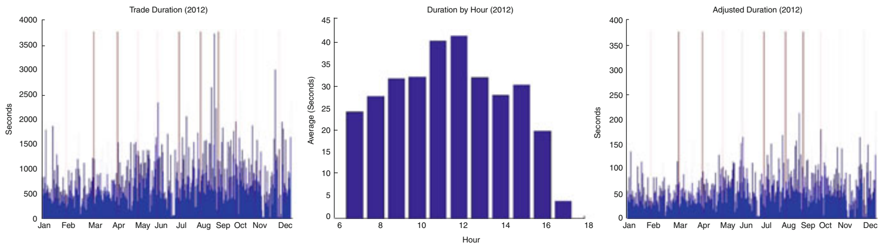

Fig. 12.3 Trading duration analysis 3-Jan to 17-Dec 2012

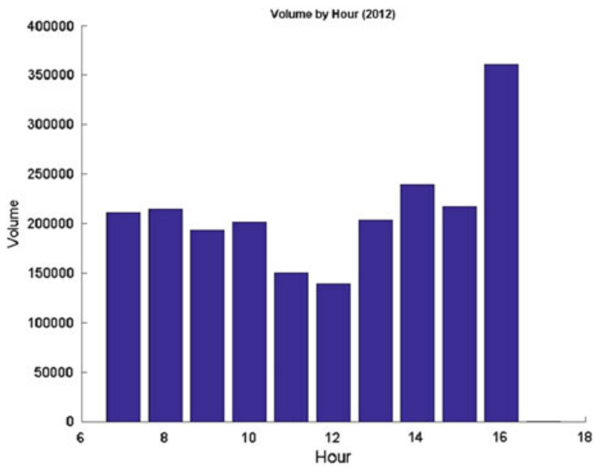

Fig. 12.4 Average volume by hour December 2012 contract

(absolute deviations from long- run monthly mean temperatures) were used to model the EUA price, with a cointegration analysis to establish the long-run relationship between the variables and the EUA price.

The six variables are: (1) Clean Dark Spread (CDS) the cost of electricity generation using coal, (2) Clean Spark Spread (CSS) the cost of electricity generation using natural gas, (3) Equity prices measured by Euro Stoxx futures (proxying economic activity), (4) Oil prices measured by Brent crude oil, (5) Production measured by industrial production, and (6) Temperature.

The CDS and CSS spreads refer to the difference of generating electricity at peak hours and the energy price (coal or gas) to produce that electricity, corrected for energy output of the plant.

Bredin and Muckley (2011) report a cointegration style regression for calculating the EUA price as follows:

$$\begin{aligned}\text{EUAt} = 20 \; &+ 0.39\,\text{CDS} - 0.43\,\text{CSS} \; + \; 0.22\,\text{Equity} \; + \; 0.87\,\text{Oil} \\ &- 0.47\,\text{Production} \; + 0.01\,\text{Temp} \; + \text{residual}\end{aligned}$$

Bredin and Muckley (2011) estimate means and variances for each regressor. These sample moments are scaled up from the daily to the yearly frequency to facilitate our Monte Carlo distribution simulations. The error term was generated from a normal distribution. The simulated years extend from 2012 up to 2020, facilitating price comparisons with other studies and reports. The intercept was given a value of 20 to centre the range of simulated prices.[13]

A method of simulating option prices as used by Gili et al. (2011) (Sect. 9.3 in Chap. 9) is adapted for use in this chapter. The modified approach generates 1,000 Geometric Brownian paths for each year arising directly from the simulated values of the regressor variables and the coefficients presented above. Each year is seeded with the previous year's means and variances. This permits the model to be unconstrained as the simulation develops.

From the simulation, eight mean returns (one for each year) were generated for each variable. These were multiplied by their coefficient and added to the error term and intercept, to produce an EUA price for the year. For consistency with the original model, the initial year was seeded with variables produced by Bredin and Muckley (2011). In order to estimate the accuracy of the simulation, the standard error was calculated as standard deviation divided by the square root of sample size from the EUA prices for the 8 years, and subsequently measured against a 95 % confidence interval.

12.4 Cost Impact to the Aviation Sector: A Simulation Model

12.4.1 Emissions Projections

The United Nation Framework Convention on Climate Change projects a steady increase in aviation emissions, increasing to 300 million tonnes by 2020 (Standard and Poor's 2011). Carbon Trust (2009) projected a range of 293–373 million tonnes of CO_2 emissions, with an expected 300 million tonnes. For our purpose, we assume a figure of 300 million tonnes by 2020 in our cost to the aviation sector calculations (Fig. 12.5).

Figure 12.6 (modified from Standard and Poor's 2011) shows projected emissions rising steadily from 250 million tonnes in 2012 to 300 million tonnes by 2020. It also

[13] The intercept is given an indicative (conservative) value of 20 Euro for three reasons. First, as previous studies have suggested prices of between 25 and 50 Euro per tonne (York Aviation, Carbon Trust and Bloomberg New Energy Finance). Second, due to the structural deficit anticipated between a carbon emissions cap of 221 million tonnes per year and the UN projection of 300 million tonnes by 2020. Finally, it is worthwhile to emphasize that the precise point estimate of the intercept is not of first order importance as the trend in simulated prices is our main point of concern.

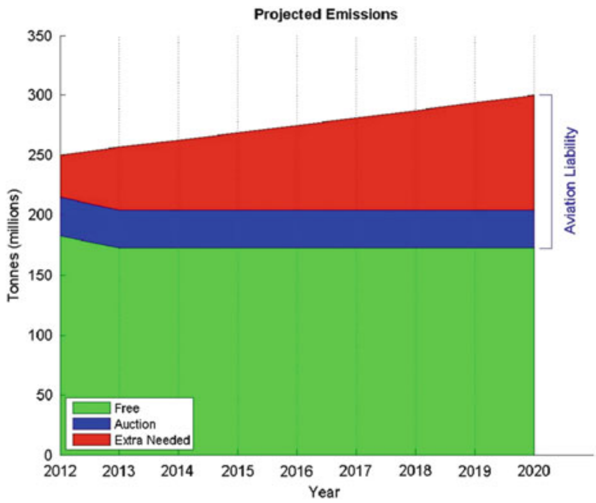

Fig. 12.5 Projected emissions (Source: Standard and Poor's 2011)

illustrates the liability to the aviation sector, depicted as the auction amount, and extra allowances required. Notably, this liability increases by 89 %, from 2012 to 2020.

12.4.2 Price Simulation Results

Thousand simulations were run for each year, from 2012 to 2020. Figure 12.6 presents the simulated prices after running the yearly simulations. The resultant price range of 17.34 Euro to 50.72 Euro per tonne of CO_2 emissions is consistent with projections used by York Aviation (2008) and Bloomberg New Energy Finance (2011).

12.4.3 Cost Scenarios

To incentivise investments towards lower emissions, it is estimated that the carbon emissions price needs to be approximately 45.00 Euro per tonne (International Energy Association). With the launch of the EUA in 2005, it opened at a price of approximately 30 Euro per tonne, but collapsed to less than 1 Euro per tonne by 2007; due to the availability of too many free allowances and the no banking restriction between phase 1 and phase 2 of the EU ETS.[14]

[14] Since the EUA price collapse in 2007 this instrument is bankable from year to year within the ETS phase II, and even between phase II and phase III of the ETS. The key issue is that intraphase banking has been allowed throughout (Phase 1, 2, 3); however interphase banking was not permitted between Phase 1 and 2. The Kyoto protocol only came into operation from 2008 onwards. The aim of Phase 1 was to get the market up and running.

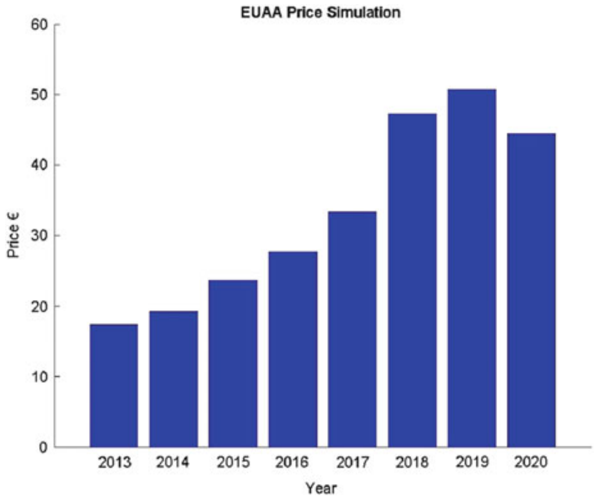

Fig. 12.6 EUAA 2012–2020 price simulation

Table 12.4 EUAA projected price range scenarios (AC billions)

Year	Allowances needed (millions)	AC 10	AC 30	AC 50	AC 70
2012	67	AC 0.674 b	AC 2.023 b	AC 3.372 b	AC 4.721 b
2013	84	AC 0.838 b	AC 2.513 b	AC 4.188 b	AC 5.863 b
2014	90	AC 0.900 b	AC 2.700 b	AC 4.501 b	AC 6.301 b
2015	96	AC 0.963 b	AC 2.888 b	AC 4.813 b	AC 6.738 b
2016	103	AC 1.025 b	AC 3.075 b	AC 5.126 b	AC 7.176 b
2017	109	AC 1.088 b	AC 3.263 b	AC 5.438 b	AC 7.613 b
2018	115	AC 1.150 b	AC 3.450 b	AC 5.751 b	AC 8.051 b
2019	121	AC 1.213 b	AC 3.638 b	AC 6.063 b	AC 8.488 b
2020	128	AC 1.275 b	AC 3.825 b	AC 6.376 b	AC 8.926 b
Total		AC 9.125 b	AC 27.376 b	AC 45.627 b	AC 63.878 b

Since 2008 and the start of phase 2, the EUA price has recovered, reaching a high of 32.4 Euro in July 2008. In the period 2009–2011, the EUA traded at prices in the range of circa 10 Euro to 20 Euro, while the corresponding range for 2012 is from circa 6 Euro to 10 Euro.

Based on the simulated price range of 17–51 Euro per tonne (Fig. 12.6), prices of 10, 30, 50 and 70 Euro were selected for further analyses. Table 12.4 provides a cost summary for EUAs at these prices.

As per York Aviation (2008), a "business as usual" model has an operating margin of 4 % for network airlines, 14 % for low fare airlines, 2 % for leisure

Table 12.5 Major airlines response to EU ETS costs

Airline	Response to EU ETS cost
Air Asia X	Currently charged at AC 5 per customer per trip
Air France/KLM	Commitment to charging, but as yet undefined
Air New Zealand	Commitment to charging, but as yet undefined
American Airlines	Currently charged at AC 3 per customer per trip
British Airways	No decision made as yet
Delta Airlines	Currently charged at AC 3 per customer per trip
Lufthansa	Charge added to fuel surcharge (EU ETS not separated)
Ryanair	Currently charged at AC 0.25 per customer per trip
Singapore Airlines	No decision made as yet
United Airlines	Currently charged at AC 3 per customer per trip

Table 12.6 EU ETS price scenarios

	EU ETS total cost 2012–2020	EU ETS annual cost	EU ETS as a % of annual profits (AC 12 billion)	EU ETS as a % of annual fleet investments (AC 35 billion)
Scenario 1 AC 10 per tonne	AC 9.125 billion	AC 1.014 billion	8 %	3 %
Scenario 2 AC 30 per tonne	AC 27.376 billion	AC 3.042 billion	25 %	9 %
Scenario 3 AC 50 per tonne	AC 45.627 billion	AC 5.070 billion	42 %	14 %
Scenario 4 AC 70 per tonne	AC 63.878 billion	AC 7.098 billion	59 %	20 %

airlines and 4 % for cargo airlines; with projected industry annual operating profits of 12 billion Euro, and an annual fleet investment program of 35 billion Euro.

Some major airlines are already increasing airfares to offset the EU ETS costs; several have announced a separate charge while others have incorporated the fee into fuel surcharges. A summary of the response of the major airlines is reported in Table 12.5.

As shown in Table 12.6, these EU ETS costs are large compared to annual operating profits and hence their impact on the aviation sector will be formidable. From these figures, it is clear that the majority of such costs will therefore be passed onto customers. As airlines routinely pass on a portion of increases in fuel costs and other charges to customers (OAG 2012; The Post and Courier 2011), it is conceivable that a significant portion of the EU ETS costs will be treated similarly.

Table 12.6 presents four scenarios and illustrates why airlines are so concerned about the introduction of the aviation sector into the scheme. At a 30 Euro per tonne projection, the EU ETS could wipe out a quarter of airline's total profits and erode available fleet investment funds by circa 10 %.[15] The latter point is salient, as the aviation industry (particularly outside the EU) is relying on fleet improvements to reduce CO_2 emissions. Any reduction in investment would contribute to emissions at current levels thereby creating an upward effect on carbon prices.

Conclusion

Our analyses of the EUA market micro-structure suggest that the market is becoming more efficient over time. We use a definition of reduced friction to interpret market efficiency. Specifically, we find very low durations (many sub second) and substantial trading volumes which together imply improved liquidity. These latter findings are consistent with enhanced market efficiency. The finding of a liquid market and increased market efficiency are not unexpected, given recent corroborative findings by Bredin and Muckley (2011) and Koch (2011).

Taking into account a carbon dioxide (CO_2) emissions cap of 221 million tonnes per year, and UN projections of 300 million tonnes by 2020, it is evident that a significant shortfall in allowances may emerge. Using a price simulation based on the work of Bredin and Muckley (2011) our results indicate a price range of 17 Euro to 51 Euro per tonne of CO_2 emissions by 2020. In addition, price selections of 10 Euro, 30 Euro, 50 Euro and 70 Euro per tonne of CO_2 will generate total costs of 9 billion Euros, 27 billion Euros, 46 billion Euros and 64 billion Euros respectively in 2012–2020. These simulated figures represent onerous new costs for the aviation sector and would be expected to incentivize a material reduction in emissions in the aviation sector in the future.

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[15] There is an expectation, on the part of the European Commission, that competition in combination with improved clean technologies in the aviation sector will incentivate a reduction in emissions and complement any pass through of flight price increases to the customer due to the ETS extension to the sector.

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