U.S. ENERGY OUTLOOK

AND FUTURE ENERGY

IMPACTS

by

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ABSTRACT

Energy markets were not immune to the 2007 financial crisis. Growth in the Indian and Chinese economies is placing strains on global energy supplies that could force a repeat of the 2008 price spike of $145/bbl for crude oil. Emerging market growth coupled with inefficiencies, frictions, and speculation in the energy markets has the potential to create drastic economic shocks throughout the world.

The 2007 economic crisis has pushed back investment in energy projects where a low-growth scenario in world GDP could create drastic price increases in world energy prices. Without a long-term energy supply plan, the U.S. is destined to see growth reduced and its trade imbalances continue to deteriorate with increasing energy costs.

Analysis of the U.S. natural gas futures markets and the impact of financial speculation on natural gas market pricing determined that financial speculation adds to price movements in the energy markets, which could cause violent swings in energy prices.

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INTRODUCTION

The U.S. is the world's largest energy consumer, using roughly 99.3 quadrillion btus of energy in 2008.[1] Roughly 31% of the U.S. energy supply is from imports, which raises questions of national security as well as balance of payment concerns. The 2007 financial crisis has curtailed business investment, and in the energy sector, where large projects can take decades to develop, a potential crisis is brewing. Due to a lack of energy development and the recent BP Gulf of Mexico crisis, energy prices could eclipse the $145/bbl price crude oil set in 2008.

Decline rates in natural gas and crude oil production require development of new reserves to maintain current production levels. As economies worldwide recover from the 2007 financial crisis, a sudden surge in economic growth could bring a commensurate spike in energy demand that could drive prices beyond the 2008 highs and destroy what appears to be a prolonged and fragile economic recovery in the U.S.

Commodity speculation was identified as a potential driver to the sudden surge in 2008 energy prices. Sanders, Irwin, and Merrin analyzed commodity futures and determined that index fund positions across futures markets have no impact on relative price changes across those markets.[2] However, Sanders, Boris, and Manfredo in 2004 asserted that "A positive

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[1] U.S. Energy Information Administration, "2008 Energy Review," http://www.eia.gov/oiaf/archive/aeo08/, 2008, p. 3, (accessed October 15, 2010).

[2] Dwight R. Sanders, Scott H. Irwin, Robert P. Merrin, "A Speculative Bubble in Commodity Futures Prices? Cross-Sectional Evidence," (Paper presented at the NCCC-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management St. Louis, Missouri, April 20-21, 2009), p. 3.

correlation between returns and positions held by noncommercial traders, and a negative correlation between commercial positions and market returns are found."[3]

Whether or not bubbles in the commodity markets are fueled by "hot money" is a subject debated by many in the academic and financial world, but as Irwin, Sanders, and Merrin noted, "for every long there is a short, for everyone who thinks the price is going up there is someone who thinks it is going down, and for everyone who trades with the flow of the market, there is someone trading against it. These are zero-sum markets where all money flows must by definition be set to zero."[4]

The laws of supply and demand still function in the futures markets, and if supply or demand is overrun by hot money, it would stand to reason that bubbles could be created in the futures markets. In *Bubbles and Crashes* by Abreu and Brunnermeir, a model is developed from an efficient market perspective. Yet the authors argue that bubbles can survive despite the presence of rational arbitrageurs where "behavioral agents" or animal spirits lead to momentum trading, trend chasing, and the like. [5] For decades, the U.S. has been the dominant player in the energy markets, but today China will impact the energy trade like no other county in the world. [6] Non-OECD (Organization for Economic Co-operation and Development) countries led by

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[3] Dwight R. Sanders, Keith Boris, Mark Manfred, "Hedgers, funds, and small speculators in the energy futures markets: an analysis of the CFTC's Commitments of Traders reports," Energy Economics Volume 26, Issue 3 (May 2004), p. 1.
[4] Dwight R. Sanders, Scott H. Irwin, and Robert Merring, "Devil or Angel? The Role of Speculation in the Recent Commodity Price Boom and Bust," Journal of Agricultural and Applied Economics, 41, 2, (August 2009), p. 379.
[5] Dilip Abreu, Markus Brunnermeit, "Bubbles and Crashes," Econometrica Vol. 71 No. 1 (January, 2003), p. 173.
[6] Antony Froggatt and Glada Lahn , Lloyds 360^{o} Risk Insight, "Sustainable Energy Security," http://www.lloyds.com/News-and-Insight/360-Risk-Insight/Research-and-Reports/Energy-Security/Energy-Security, 2010, p. 9, (accessed October 1, 2010).

China and India are reshaping world energy demand. Projections into 2015 note a tipping point where Asia-Pacific countries need more imported oil than the Middle East can provide.[7]

Recently the debates regarding greenhouse gases and renewable energy have brought U.S. energy policies into focus. However, based on the 2006 NPC U.S. Energy study, fossil fuels will remain a dominant source of energy in the United States. The U.S. is fortunate to have an abundant supply of coal and natural gas that would allow it to become more energy self-sufficient if those resources were used with an emphasis on both market and thermal efficiency.

Studies by the IEA (International Energy Agency), EIA (Energy Information Administration), and NPC (National Petroleum Council) all point to increased energy demand growth in the 2030-2035 time frame. There is considerable uncertainty as to where future supplies will come from. Cheap energy has been a boom for globalization. As an example:

- Raw materials mined in Australia are shipped to China for processing into steel.
- The steel can then be shipped to another country for manufacturing into an intermediate good.
- That intermediate good is then shipped to yet another country for assembly into the final product.
- Lastly, that final product could be shipped to markets on other continents for final sale.

[7] Antony Froggatt and Glada Lahn , Lloyds 360^{o} Risk Insight, “Sustainable Energy Security,” p. 10.

The point is that low-priced energy has allowed industrialization to take advantage of cheap labor throughout the world, but that could all change if crude were to spike to over $150/bbl. Massive increases in energy costs will cause transportation costs to outweigh the advantages of cheap labor. Figure 1 shows the projected future energy demand broken down by energy source.

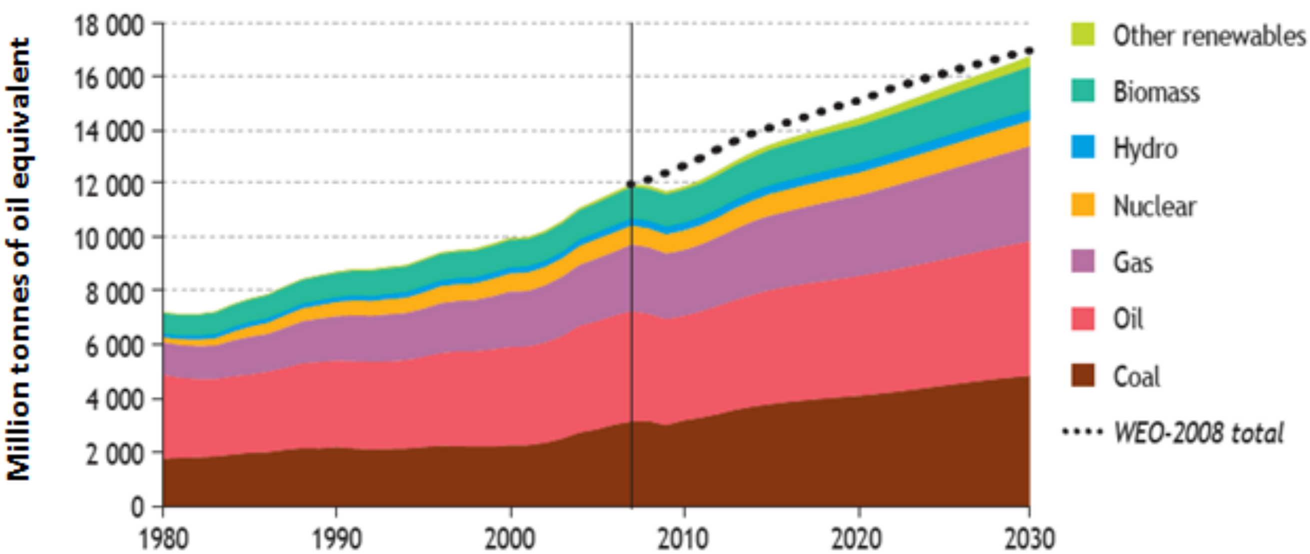

Figure 1. IEA World Primary Energy Demand[8]

1 toe (ton oil equivalent) = 7.33 boe (barrel oil equivalent) –or- 1 mtoe = 7,330,000 boe

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[8] International Energy Agency, "World Energy Outlook 2009," http://www.iea.org/weo/2009.asp, 2009, p. 75, (accessed November 1, 2010).

U.S. AND WORLD ENERGY CONSUMPTION

The United States ranks first in world oil consumption followed by China, Japan, India, Russia, Germany, and Brazil.[9] Historically, OECD countries have been the key consumers that have driven world energy demand, but the emerging markets of China and India are reshaping the energy demand as their economies grow. As in the OECD countries, the growth in transportation fuels is becoming a significant component in the growth of these emerging markets.

Projections of world energy use are available from a variety of sources.

- EIA (U.S. Energy Information Administration)
- IEA (International Energy Association)
- OPEC (Organization of Petroleum Exporting Countries)
- BP (British Petroleum)
- NPC (National Petroleum Council)
- Academic Papers (Dargay and Gately)

[9] U.S. Energy Information Administration, "Annual Energy Review 2009," http://www.eia.doe.gov/aer/pdf/aer.pdf, 2009, p. 324, (accessed October 1, 2010).

All of the analyses of future energy demand by the above sources in the 2030-2035 timeframe project that hydrocarbon fuels will remain a key component in the world's energy portfolio. Furthermore, coal use will continue to grow to meet the demands of emerging countries such as India and China. China's coal demand is outpacing its domestic production, which is forcing the country to import coal to satisfy its markets. Similar to China, industrial growth in India has created electrical shortages of up to 14% of demand. India's plan to close their electrical gap is to construct coal-fueled electrical power plants.

Based on the following U.S. energy prices, a comparison can be made of fuel costs when converted to a common energy basis.

Petroleum	\$85/bbl (1 bbl = 5,800,000 btu)
Natural Gas	\$4.00/mmbtu (1 mmbtu = 1,000,000 btu)
Coal	\$12.35/short ton (Cheap Coal 8,800 btu/lb), \$62.75/short ton (Expensive Coal 13,000 btu/lb)

As shown in Table 1, coal is the least expensive fuel on a mmbtu basis.

The energy prices in Table 1 do not reflect transportation costs nor do they take into account the costs of the externalities associated with hydrocarbon fuels. In the U.S. as in many OECD countries, there has been a push toward green or renewable energy that has a minimal or even zero carbon footprint. However, as the NPC points out in its "Hard Truths" energy analysis, green and renewable energy are incapable of providing the world's energy needs by

Table 1. U.S. Energy Equivalent Pricing

Fuel	\$/mmbtu
Petroleum	\$14.66
Natural Gas	\$4.00
Coal	\$0.7017 (cheap coal), \$2.4135 (expensive coal)

themselves. Therefore, countries throughout the world are facing a difficult decision as to how to weigh energy security, cost, and the externalities that society must bear given the type of energy used. Table 2 shows the various pollutant emissions for the common energy sources used throughout the world.

The externality most often discussed with hydrocarbon fuels is GHG (Greenhouse Gases). When GHGs are taken into account, coal becomes the hydrocarbon fuel with the highest externality. Until a carbon tax is initiated worldwide, corporations will be able to shift production from countries with carbon taxes to those without. Global warming caused by greenhouse gases has the potential to cause further economic hardships due to drastic swings in weather. Periods of extreme hot, cold, dry, and wet will impact food production, transportation, and industrial production.

Table 2. Fossil Fuel Emissions (Pounds per Billion btu of energy input)[10]

Pollutant	Natural Gas	Oil	Coal
Carbon Dioxide	117,000	164,000	208,000
Carbon Monoxide	40	33	208
Nitrogen Oxides	92	448	457
Sulfur Dioxide	1	1,122	2,591
Particulates	7	84	2,744
Mercury	0.000	0.007	0.016

[10] Natural Gas, "Natural Gas and the Environment," http://www.naturalgas.org/environment/naturalgas.asp, (accessed November 4, 2010).

The world is facing the potential of an acute energy shortage based on the growth in the emerging markets and the lack of a comprehensive energy plan. The U.S. has continued without a comprehensive energy plan since peak petroleum production occurred in 1970. The specter of "peak oil" as shown in Figure 2 is sometimes discussed where world oil production will peak and decline similar to what occurred in the U.S.

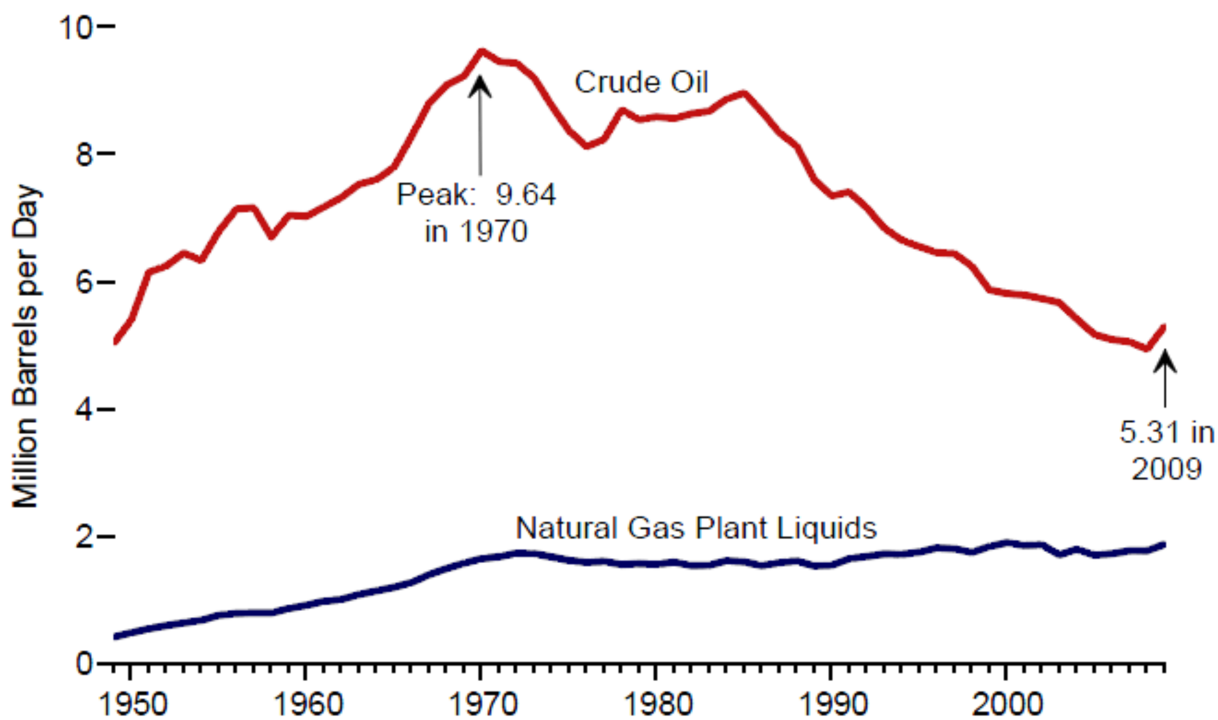

Figure 2. U.S. Crude and Natural Gas Plant Liquids Production[11]

[11] U.S. Energy Information Administration, "Annual Energy Review 2009," http://www.eia.doe.gov/aer/pdf/aer.pdf, 2009, p. 128, (accessed October 1, 2010).

Opponents of the peak oil theory note that technical innovations such as 3D seismic, hydraulic fracturing, and deep water drilling have brought reserves to the market that have been able to satisfy world demand. However, given the recent economic slowdown coupled with the time it takes to develop significant energy projects, the world's surplus energy production is dwindling rapidly. By 2015, Lloyds of London predicts that Asia-Pacific demand will surpass Middle East surplus capacity (see Figure 3).

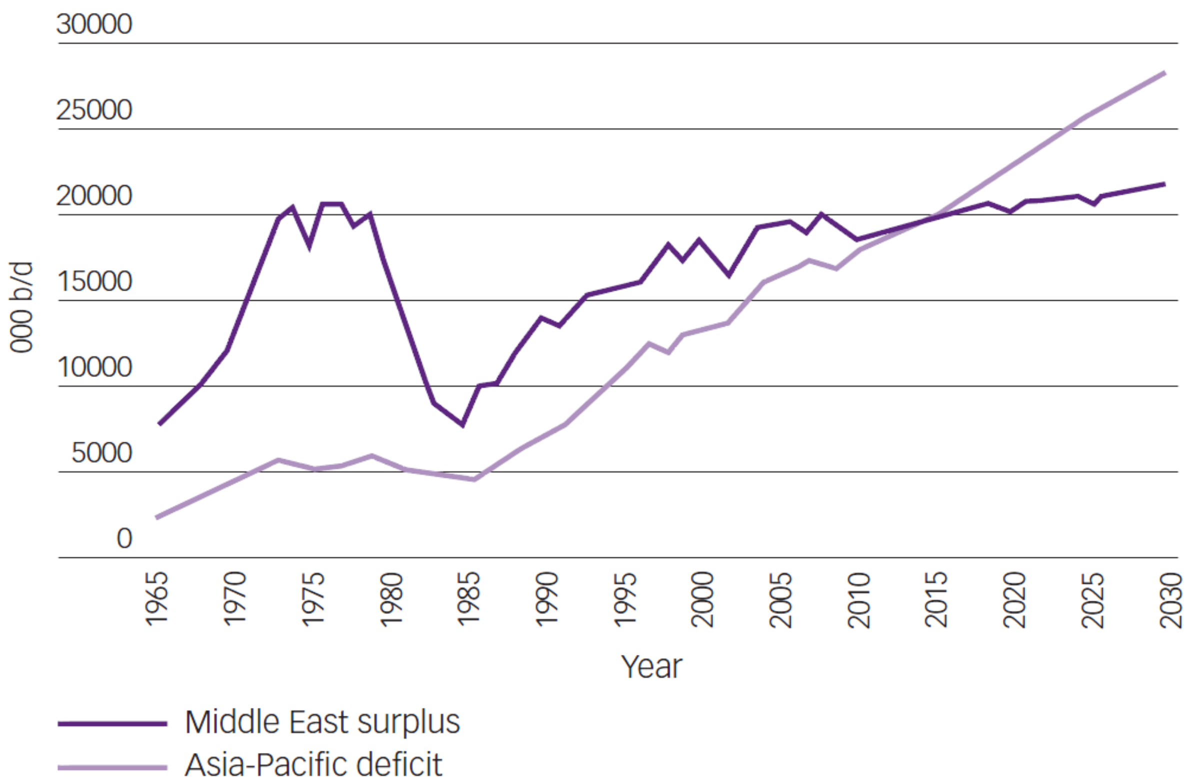

Figure 3. Middle East Oil Surplus versus Asia-Pacific Oil Deficit[12]

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[12] Antony Froggatt and Glada Lahn , Lloyds 360° Risk Insight, "Sustainable Energy Security," http://www.lloyds.com/News-and-Insight/360-Risk-Insight/Research-and-Reports/Energy-Security/Energy-Security, 2010, p. 10, (accessed October 1, 2010).

The 2007 Financial Crisis Impact on Energy Production

The 2007 Financial Crisis has impacted markets throughout the globe. The energy markets were not immune. Shortly after the crisis, oil reached a high of $145/bbl in July 2008 only to retreat to a low of $37/bbl in December 2008. Faced with a period of price uncertainty, energy companies began to curtail energy projects. The long duration of energy projects and the NPV (Net Present Value) used to evaluate their economics make them extremely sensitive to pricing in the early years of production. Prior to the recent plunge in interest rates, firms used a cost of capital of 8 to 10 percent to determine whether projects generated positive cash flow. In addition to the cost of capital, project risk factors also impact return hurdle rates, which vary by corporation.

Given the tentative economic outlook, along with the current price uncertainty, many energy companies have chosen to forego energy exploration and development and rather obtain reserves through acquisitions or attempt to increase shareholder value by buy-back of shares. On October 4, 2010, Chevron Corporation announced a buy-back program of up to $1 billion. Exxon-Mobil has utilized a similar strategy of stock buy-backs to boost share price. Sixty percent of Exxon's cash flow or $29 billion was spent on stock repurchases in 2006.[13] Prior to Chevron's recent repurchase announcement, it bought back some $4.5 billion of its stock in 2006, vs. $2.6 billion the prior year. Overall, the industry spent $52.4 billion on buybacks last year, nearly double the amount in 2005.[14]

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[13] Businessweek, "Pumping Cash, Not Oil," http://www.businessweek.com/magazine/content/07_22/b4036057.htm, May 28, 2007, (accessed November 5, 2010).
[14] Businessweek, "Pumping Cash, Not Oil."

Meanwhile the IEA estimates that world energy investment needs $16 trillion through 2030 to maintain and expand energy supply.[15] An estimated investment of $4 trillion is needed in upstream investment in the oil and gas sector to maintain existing production.[16] Investments of these magnitudes require a consistent approach to project development and execution to counter decline rates in existing production as well as discover new sources of energy. Using the $4 trillion investment figure mentioned above, the oil and gas industry would need to maintain an average investment rate of $200 billion/year to achieve the IEA threshold.

The IEA outlines the following future energy challenges and opportunities:[17]

> The financial crisis brings a temporary reprieve from rising fossil energy use
>
> Global energy use is set to fall in 2009 — for the first time since 1981 on any significant scale — as a result of the financial and economic crisis; but, on current policies, it would quickly resume its long-term upward trend once economic recovery is underway. In our Reference Scenario, world primary energy demand is projected to increase by 1.5% per year between 2007 and 2030, from just over 12 000 million tonnes of oil equivalent (Mtoe) to 16 800 Mtoe — an overall increase of 40%. Developing Asian countries are the main drivers of this growth, followed by the Middle East. Projected demand growth is slower than in WEO-2008, reflecting mainly the impact of the crisis in the early part of the projection period, as well as of new government policies introduced during the past year. On average, demand declines marginally in 2007-2010, as a result of a sharp drop in 2009 — preliminary data point to a fall in that year of up to 2%. Demand growth rebounds thereafter, averaging 2.5% per year in 2010-2015. The pace of demand growth slackens progressively after 2015, as emerging economies mature and global population growth slows.
>
> Fossil fuels remain the dominant sources of primary energy worldwide in the Reference Scenario, accounting for more than three-quarters of the overall increase in energy use between 2007 and 2030. In absolute terms, coal sees by far the biggest increase in demand over the projection period, followed by gas and oil. Yet oil remains the single largest fuel in the primary fuel mix in 2030, even though its share drops, from 34% now

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[15] International Energy Agency, Press Release, http://www.iea.org/press/pressdetail.asp?PRESS_REL_ID=107, November 4, 2003, (accessed October 24, 2010).
[16] International Energy Agency, Press Release.
[17] International Energy Agency, "World Energy Outlook 2009," http://www.iea.org/weo/2009.asp, 2009, pp. 42-43, (accessed November 1, 2010).

> to 30%. Oil demand (excluding biofuels) is projected to grow by 1% per year on average over the projection period, from 85 million barrels per day in 2008 to 105 mb/d in 2030. All the growth comes from non-OECD countries: OECD demand actually falls. The transport sector accounts for 97% of the increase in oil use. As conventional oil production in countries not belonging to the Organization of the Petroleum Exporting Countries (OPEC) peaks around 2010, most of the increase in output would need to come from OPEC countries, which hold the bulk of remaining recoverable conventional oil resources.
>
> The main driver of demand for coal and gas is the inexorable growth in energy needs for power generation**.** World electricity demand is projected to grow at an annual rate of 2.5% to 2030. Over 80% of the growth takes place in non-OECD countries. Globally, additions to power-generation capacity total 4,800 gigawatts (GW) by 2030 — almost five times the existing capacity of the United States. The largest additions (around 28% of the total) occur in China. Coal remains the backbone fuel of the power sector, its share of the global generation mix rising by three percentage points to 44% in 2030. Nuclear power output grows in all major regions bar Europe, but its share in total generation falls.
>
> The use of non-hydro modern renewable energy technologies (including wind, solar, geothermal, tide and wave energy, and bio-energy) sees the fastest rate of increase in the Reference Scenario**.** Most of the increase is in power generation: the share of non-hydro renewables in total power output rises from 2.5% in 2007 to 8.6% in 2030, with wind power seeing the biggest absolute increase. The consumption of biofuels for transport also rises strongly. The share of hydropower, by contrast, drops from 16% to 14%.

Another downside to the 2007 financial crisis is the hiring slowdown for engineering and science graduates. Per the NPC report "Hard Truths," a majority of the U.S. energy sector workforce, including skilled scientists, is eligible to retire in the next decade.[18] The boom and bust cycle of the energy industry coupled with the recent BP Gulf of Mexico disaster have caused bright young professionals to spurn the energy industry. The speculation has been that the brightest students have opted for careers in the financial industry versus a career as an engineer.

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[18] National Petroleum Council Presentation, "Facing the Hard Truths about Energy," http://www.npchardtruthsreport.org/, 2007, p. 31, (accessed October 1, 2010).

The U.S. DARPA (Defense Advanced Research Project Agency) noted the following in a research announcement to encourage students to enroll in CS-STEM (Computer Science – Science, Technology, Engineering, and Mathematics) fields.[19]

> The United States has entered into a significant national decline in the number of college graduates with STEM degrees. This downward trend is an issue of national importance as it affects our capacity to maintain a technological lead in critical skills and disciplines related to CS-STEM. Our ability to compete in the increasingly internationalized stage will be hindered without college graduates with the ability to understand and innovate cutting edge technologies in the decades to come.
>
> The downward trend in college graduates with STEM majors is particularly pronounced in Computer Science (CS). While computers and Internet connectivity become daily fixtures in the lives of Americans, we are steadily losing the engineering talent to project these systems. According to the Computer Research Association, there were 43% fewer graduates and 45% fewer CS degree enrollments in 2006/2007 than in 2003/2004.

The decrease in CS degree enrollment is likely attributed to two things. First, the dot-com bubble enticed students to enroll in the computer science field. When the bubble burst, the abundance of jobs and opportunities appeared to disappear overnight. Secondly, globalization of IT (Information Technology) work has eliminated many U.S. jobs where students graduating with CS degrees have difficulty finding jobs. Further complicating the job economic plight of graduates is the impact of the 2007 Financial Crisis where hiring of recent graduates in virtually all technical fields has ground to a halt as companies slow plans for expansions and new projects. The energy industry has seen numerous episodes of wild price swings, which mimic the impact of the 2007 financial crisis. At the peak of the energy price bubble, the industry is faced with a shortage of new and experienced talent, which bids up salaries. Inevitably as the bubble crashes,

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[19] Defense Advances Research Products Agency, "DARPA-RA-10-03 Computer Science – Science, Technology, Engineering, and Mathematics (CS-STEM) Education Research Announcement," https://www.fbo.gov/index?s=opportunity&mode=form&tab=core&id=88b3ebc24fb6377fac6b1107d8d96b84&_cview=0, 2010, p. 4, (accessed October 29, 2010).

layoffs result and recent college graduates hoping to find jobs in the energy sector are left to find careers elsewhere.

Emerging Market Energy Growth

Throughout the financial crisis, the emerging markets of Brazil, China, and India have fallen less and have recovered faster than OECD countries. China, India, and Brazil will be three of the largest emerging economies to impact the global supply of oil.[20] Figure 4 depicts the trend in Chinese oil consumption, which points to an economy that is acquiring a voracious appetite for oil.

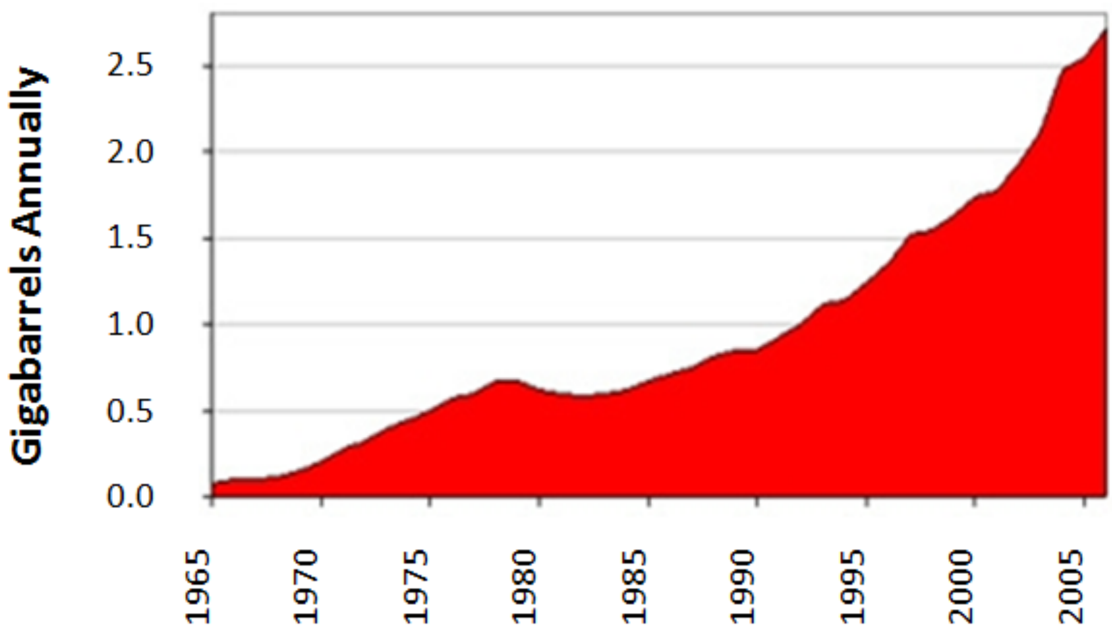

Figure 4. Chinese Oil Demand[21]

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[20] Alexander Smith, "Oil is Spiking – Are you positioned?" Seeking Alpha, http://seekingalpha.com/article/228660-oil-is-spiking-are-you-positioned?source=feed, October 6, 2010, (accessed October 31, 2010).
[21] Alexander Smith, "Oil is Spiking – Are you positioned?" Seeking Alpha, http://seekingalpha.com/article/228660-oil-is-spik17ing-are-you-positioned?source=feed, October 6, 2010, (accessed October 31, 2010).

As an individual country, China is the number one exporter in the world. Recently it overtook Japan as the world's number two economy behind the U.S. Another milestone that China has achieved is that it is now the world's largest manufacturer of automobiles.[22] Speculation is ongoing as to when China will overtake the U.S. as the world's number one economy in addition to becoming the world's number one consumer of oil. Currently China is the third largest importer of oil while 15 years ago it was a net exporter. In terms of consumption, China is the second largest consumer of oil in the world second only to the U.S.[23]

Various projections exist for world oil demand. Dargay and Gately have authored a paper that projects world energy demand to be 20% higher than the U.S. Department of Energy, International Energy Association (IEA), and OPEC estimates.[24] In their analysis of world oil demand, Dargay and Gately predict that world per capita oil demand will grow to 1.8 liters/day by 2030, which is in contrast to the 2009 IEA and OPEC projects of 1.2 liters/day. The 1.8 liter/day consumption rate is based on a historical rest-of-world growth rate. This higher projection figure amounts to an extra 20 million barrels of oil per day in demand, which is roughly twice the current production of Saudi Arabia.[25]

India is also a major contributor to increases in world energy demand. Rapid growth and industrialization have created a peak hour electricity shortage of 14% that has firms scrambling to expand generation and transmission capacity to handle urbanization and

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[22] World Bank, "The Recovery," http://siteresources.worldbank.org/INTEAPHALFYEARLYUPDATE/Resources/550192-1270538603148/eap_april2010_ch1.pdf, April 2010, p. 3, (accessed October 31, 2010).
[23] Alexander Smith, "Oil is Spiking – Are you positioned?" Seeking Alpha.
[24] Joyce M. Darday, Dermot Gately, "World oil demand's shift toward faster growing and less price-responsive products and regions," www.econ.nyu.edu/user/nyarkoy/OilDemand_DargayGately_Feb2010.pdf, 2010, p. 1, (accessed November 3, 2010).
[25] Joyce M. Darday, Dermot Gately, "World oil demand's shift toward faster growing and less price-responsive products and regions," p. 29.

industrialization.[26] It was previously mentioned that in the last 15 years China went from a net exporter of petroleum to a net importer. A similar situation has occurred in the coal markets. Both India and China lay claim to the world's third and fifth largest coal reserves, respectively. However, their consumption is running faster than they can develop mines. In the last five years, China has gone from a major exporter of coal to a net importer.[27]

The Council on Foreign relations recently published an article titled "China Will Force the World Off Oil." The argument made in the article describes the energy peril facing the world as countries such as China raises the income level of their poor (Figure 5).

> As a country's per capita income increases, its per capita oil consumption increases. Consumption growth tends to be modest up until $15,000 income per head, but then accelerates rapidly. China is quickly approaching this point. South Korea, which consumes 3% of world oil output, is too small to disrupt oil markets. China is too big not to disrupt them. Were China's per capita oil consumption to be brought up to South Korea's, its share of global consumption would increase from today's 10% to over 70%. In order to cap China's share at 22%, which is the U.S. share today, global oil output would have to increase by a massive 13% per annum over ten years – well beyond the 1% growth averaged since 1975. This rate of growth is inconceivable, even if vastly more expensive sources of supply, such as the Canadian oil sands, were developed at breakneck speed. If China's recent economic growth pace continues, it will surpass South Korea's current per capita GDP shortly after 2020 – meaning that the world may be forced onto alternative energy sources much sooner than it realizes. [28]

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[26] World Market Pulse, "Huge Indian Demand to drive Global Coal Export Boom," http://worldmarketpulse.com/Investing/Exchange-Traded-Funds/Industry-Sector-ETF/Energy-ETF/Huge-Indian-Demand-to-Drive-Global-Coal-Export-Boom.html, October 1, 2010, (accessed October 29, 2010).
[27] Antony Froggatt and Glada Lahn , Lloyds 360° Risk Insight, "Sustainable Energy Security," http://www.lloyds.com/News-and-Insight/360-Risk-Insight/Research-and-Reports/Energy-Security/Energy-Security, , 2010, p. 11 (accessed October 1, 2010).
[28] Council on Foreign Relations, "China Will Force the World Off Oil," http://blogs.cfr.org/geographics/2010/08/23/chinasoilconsumption/, August 23, 2010, (accessed November 5, 2010).

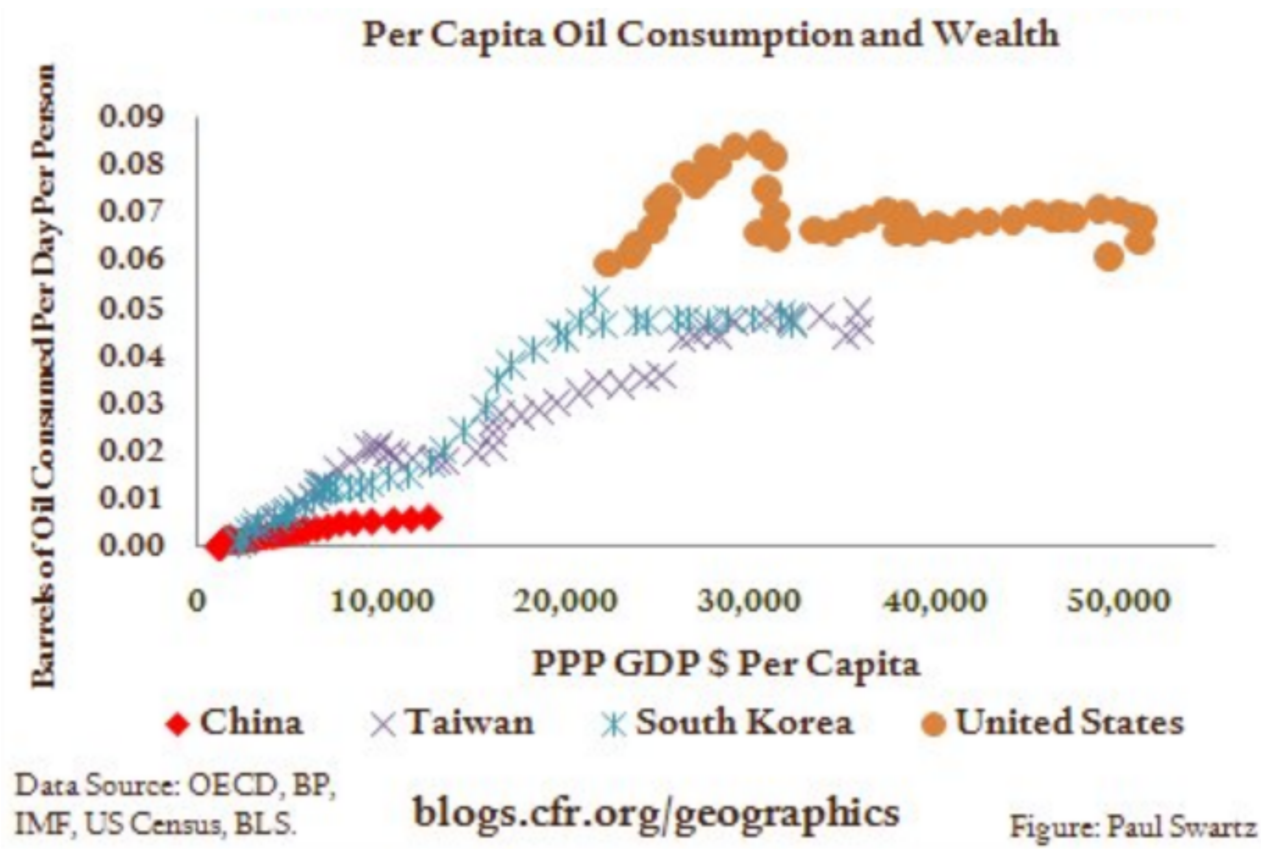

Figure 5. Per Capita Oil Consumption and Wealth[29]

[29] Council on Foreign Relations, "China Will Force the World Off Oil," http://blogs.cfr.org/geographics/2010/08/23/chinasoilconsumption/, August 23, 2010, (accessed November 5, 2010).

Per the International Energy Agency, China has now overtaken the U.S. as the world's number one energy consumer.

> IEA calculations based on preliminary data show that China has now overtaken the United States to become the world's largest energy user. China's rise to the top ranking was faster than expected as it was much less affected by the global financial crisis than the United States.
>
> For those who have been following energy consumption trends closely, this does not come as a surprise. What is more important is the phenomenal growth in demand that has taken place in China over the last decade; also prospects for future growth still remain incredibly strong. Since 2000, China's energy demand has doubled, yet on a per capita basis it is still only around one-third of the OECD average. Prospects for further growth are very strong considering the country's low per-capita consumption level and the fact that China is the most populous nation on the planet, with more than 1.3 billion people.[30]

Increases in Greenhouse Gases Due to New Electrical Generation

As mentioned previously, coal is priced as a relatively cheap fuel sans a carbon tax and accounting for global warming externalities. Cheap coal is 17.5% the cost of natural gas and 2.0% the cost of oil on an equivalent energy basis ($/mmbtu). Hence, coal is a source of cheap fuel, making it a logical choice for emerging economies to use for electrical generation. In India, coal powers 75% of the electrical plants. Imports of coal to India are expected to rise to 100 million metric tons in 2011/2012 from an estimated current usage of 80 million metric tons presently. China has become a net coal importer, which now accounts for nearly half of all

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[30] International Energy Agency, "China overtakes the United States to become the world's largest energy consumer," http://www.iea.org/index_info.asp?id=1479, July 20, 2010, (accessed November 5, 2010).

global coal demand.[31] The rapid growth in coal consumption for India and China will cause a commensurate increase in GHG. Based on the articles reviewed for this thesis, there has been no mention of any CO_2 capture or sequestration for facilities under construction or proposed for either country. Although China has been mentioned as having plans to install significant renewable energy sources (primarily wind), there is usually an equal capacity of backup power installed in the form of coal-fired plants.

Infrastructure Impact on U.S. Energy Policy

A recent push has occurred in the U.S. to make electric vehicles a significant part of the transportation sector. However, the electrical infrastructure in the U.S. is in need of investment and lacks the ability to efficiently produce and distribute electricity to power electric vehicles.

America operates a fleet of approximately 10,000 power plants. The average thermal efficiency of a power plant is roughly 33%. Efficiency has not changed much since 1960 because of slow turnover of the capital stock and the inherent inefficiency of central power generation that cannot recycle heat. Power plants are generally long-lived investments; the majority of the existing capacity is 30 or more years old.[32] The U.S. power grid was estimated to experience 6.5% in losses in 2007 which further diminishes efficiency.[33] This results in a 26.5% overall energy efficiency by the time power gets to the desired location.

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[31] World Market Pulse, "Huge Indian Demand to drive Global Coal Export Boom," http://worldmarketpulse.com/Investing/Exchange-Traded-Funds/Industry-Sector-ETF/Energy-ETF/Huge-Indian-Demand-to-Drive-Global-Coal-Export-Boom.html, October 1, 2010, (accessed October 29, 2010).
[32] U.S. Department of Energy Office of Electricity Delivery and Energy Reliability Gridworks, "Overview of the Electrical Grid," http://sites.energetics.com/gridworks/grid.html, 2007, (accessed April 12, 2010).
[33] Wikipedia, "Electric Power Transmission," http://en.wikipedia.org/wiki/Electric_power_transmission, (accessed April 12, 2010).

From a holistic standpoint, the ability to offer affordable, efficient, green transportation to the masses has shortcomings that will need to be addressed to make electric cars a viable option for the average commuter. Similar efforts have been put forth for railroads where the industry has been encouraged to embrace electric power in place of diesel fuel. In Europe, electrification of freight rail has occurred only to drive up freight transportation prices forcing shippers to move their cargo via truck versus rail.

U.S. Coal and Natural Gas Reserves

As of January 1, 2009, the recoverable reserves (Figure 6) at producing coalmines were 17.9 billion short tons (one short ton is 2,000 pounds).[34]

In addition to coal resources, the U.S. also has a large amount of conventional and unconventional natural gas reserves (Figure 7) that are being explored in light of current pricing, new directional drilling, and hydro-fracturing techniques.

As of December 31, 2007, estimated proved reserves of "dry natural gas" (consumer-grade natural gas) in the United States were 237.7 trillion cubic feet (Tcf). The United States consumed 23.2 Tcf of natural gas in 2007.

Record-high additions to U.S. dry natural gas proved reserves[35] in 2007 totaled 46.1 Tcf. The dry natural gas reserve additions mostly reflected the rapid development of unconventional

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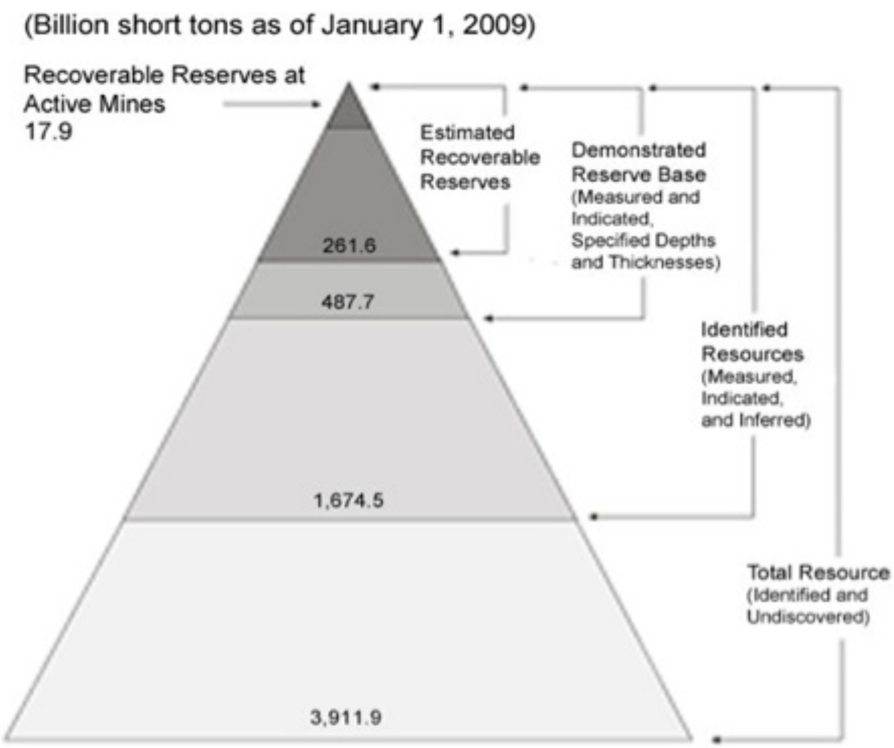
[34] U.S. Energy Information Administration, Independent Statistics and Analysis, "Coal Explained – How Much Coal is Left," http://www.eia.doe.gov/energyexplained/index.cfm?page=coal_reserves, 2009, (accessed October 31, 2010).

[35] Proven reserves are such estimated quantities of mineral deposits, at a specific date, as analysis of geologic engineering data demonstrates with reasonable certainty to be recoverable in the future under the same economic and operational conditions, http://stats.oecd.org/glossary/detail.asp?ID=2187, last revised December 2, 2005, (accessed December 12, 2010).



Source: U.S. Energy Information Administration, Form EIA-7A, Coal Production Report (February 2009)

Figure 6. U.S. Coal Resources and Reserves

gas resources including shale, coalbed methane, and tight, low-permeability formations. Many of these unconventional resources are cost effective to develop because of advances in drilling technologies and in techniques to increase gas yields from these formations and because of increases in market prices for natural gas.[36]

As of January 1, 2008, the U.S. had technically recoverable natural gas reserves[37] of 2,118.7 trillion cubic feet.[38]

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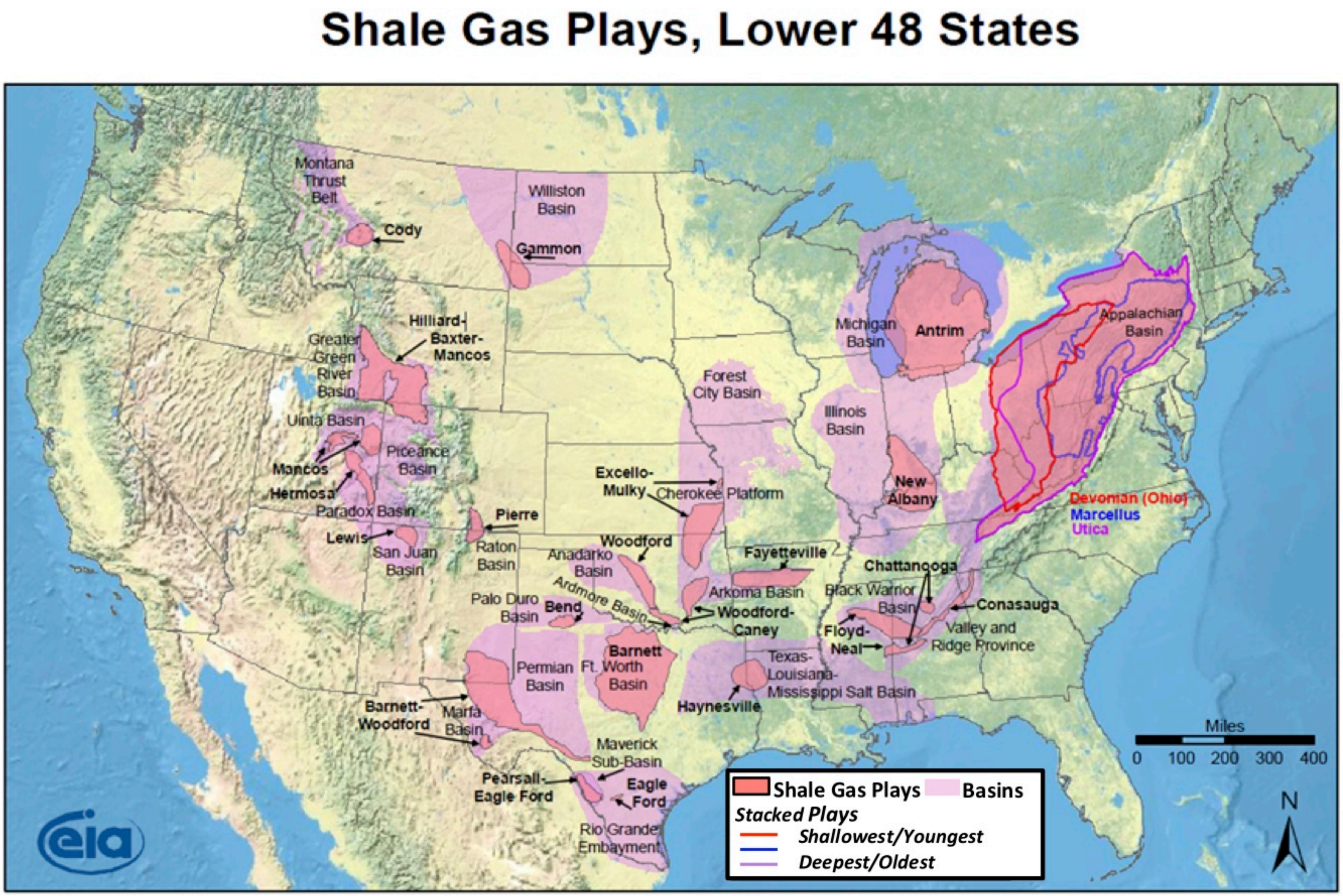
[36] U.S. Energy Information Administration, Independent Statistics and Analysis, "Natural Gas Explained – How Much Gas Is Left," http://www.eia.doe.gov/energyexplained/index.cfm?page=natural_gas_reserves, 2010, (accessed November 7, 2010).

[37] Technically resources, implies that the technology exists (or is foreseeable in the near future) to get economically unrecoverable resources from the ground, but the economics do not exist to make the production of this natural gas profitable, http://www.naturalgas.org/overview/ng_resource_base.asp, (accessed December 12, 2010).

[38] U.S. Energy Information Administration, "Oil and Gas Supply Module," http://www.eia.doe.gov/oiaf/aeo/assumption/pdf/oil_gas.pdf, April 2010, p. 111, (accessed November 3, 2010).



Source: Energy Information Administration based on data from various published studies Updated: May 28, 2009

Figure 7. U.S. Shale Gas Deposits

U.S. Energy Sector Breakdown

Energy is a key component in the manufacture and distribution of all economic goods. As a percent of GDP, energy was declining until 1999, which saw a trend reversal (see Figure 8). A gradually weakening dollar also raises the country's energy bill. The U.S. balance of payments has averaged a deficit for goods of over $500 billion per year since 2003. Based on EIA weekly petroleum import data,[39] the U.S. imports roughly 13,000,000 barrels per day of oil and petroleum products.

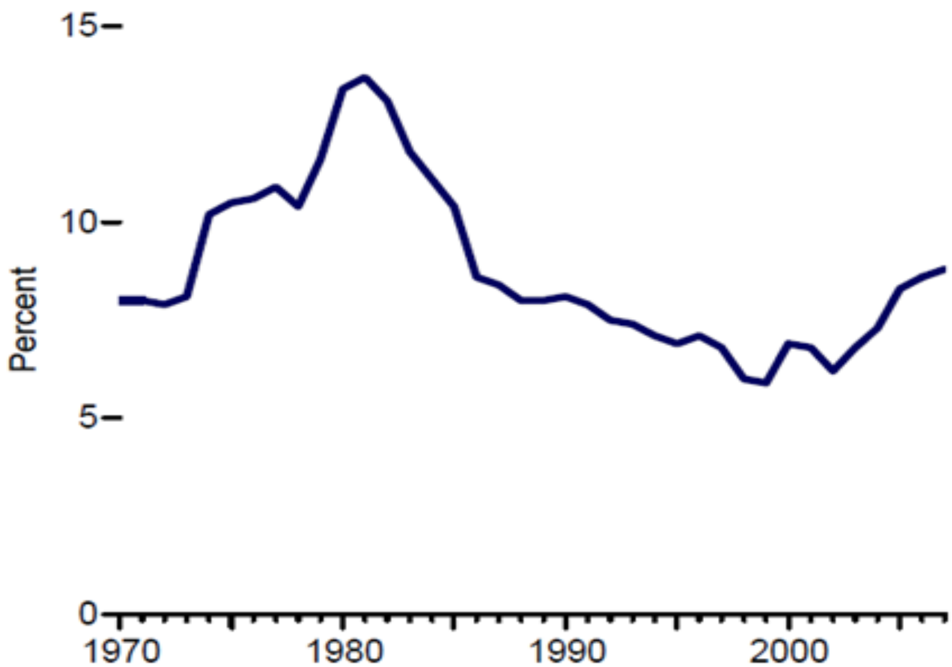


Figure 8. Energy Expenditures as a Share of U.S. GDP 1970-2007

Source: EIA 2009 Energy Summary

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[39]U.S. Energy Information Administration, "Weekly Imports and Exports," http://www.eia.gov/dnav/pet/pet_move_wkly_dc_NUS-Z00_mbblpd_w.htm, October 2010, (accessed October 31, 2010).

Assuming an approximate cost of $85 per barrel, the cost of oil and petroleum imports totals roughly $403 billion dollars per year.

Transportation Fuels

The U.S. transportation sector continued to show significant growth until the 2007 economic meltdown. As manufacturing in the U.S. continues to decline, the transportation sector is now poised to become the largest consuming energy sector in the U.S. Until 2007, transportation also had the fastest growth rate of the four energy use sectors (see Figure 9).

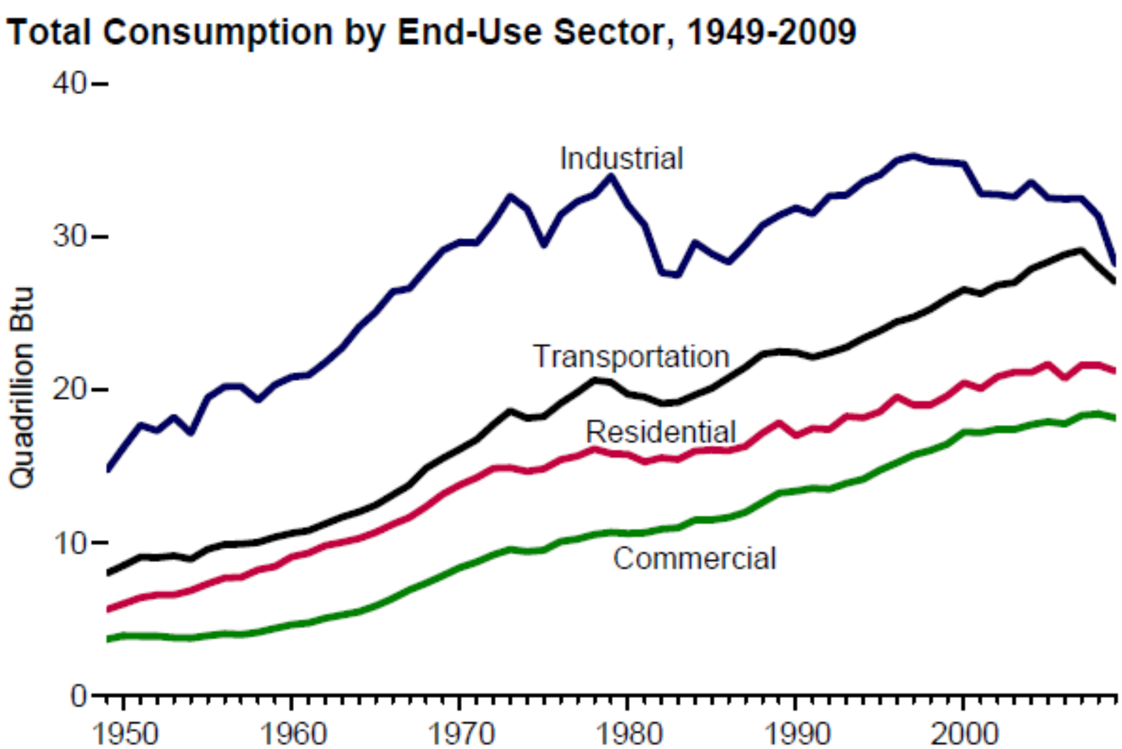

Figure 9. U.S. Sector Energy Consumption

Source: EIA 2009 Annual Energy Review

Transportation fuel currently accounts for only 0.15% of total U.S. demand for natural gas[40] and is the largest consuming sector of petroleum in the U.S. (27,033 trillion btus in 2009). 13.3 million barrels/day, or 71% of all petroleum used in 2009, was consumed by the U.S. Transportation sector. The MIT Study on the Future of Natural Gas notes:

> Use of CNG as a vehicular fuel is well established and growing worldwide. Increased use of natural gas to provide a vehicular fuel in the U.S., either directly or perhaps indirectly by conversion into a liquid fuel, could be driven by lower prices for natural gas relative to oil and by policies aimed at reducing oil dependence and GHG emissions. CNG use reduces GHG emissions by around 25% relative to gasoline.[41]

The EIA has projected natural gas to maintain its cost advantage over diesel fuel making it an attractive transportation fuel alternative. In the transportation of freight, LNG (Liquefied Natural gas) has the potential to fuel heavy-duty trucks in place of diesel fuel. Trucking markets in the U.S. consume an estimated 17 billion gallons per year of diesel fuel.[42]

Other large fuel users in the U.S. are the shipping and railroad markets. These markets represent potential markets for LNG as a transportation fuel. The rail market in the U.S. is a 4 billion gallon per year consumer of diesel fuel. The rail industry began experimenting with LNG in 1995 as a means to reduce emissions. Rail LNG technology did not prove reliable and cost effective. However, recent natural gas prices of $3.40/mmbtu equate to $0.442/dge (diesel gallon

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[40] MIT, "The Future of Natural Gas," http://web.mit.edu/mitei/research/studies/report-natural-gas.pdf, 2010, p. 50, (accessed November 6, 2010).
[41] MIT, "The Future of Natural Gas," http://web.mit.edu/mitei/research/studies/report-natural-gas.pdf, 2010, p. 50, (accessed November 6, 2010).
[42] U.S. Energy Information Administration, "Annual Energy Outlook 2010," http://www.eia.gov/oiaf/archive/aeo10/index.html, 2010, p. 33, (accessed November 3, 2010).

equivalent). This compares to an average diesel price of roughly $3/gallon.[43] The current cost difference between LNG and diesel yields a margin of $2.558/gallon, which serves as an incentive to switch from diesel fuel to LNG. As shown in Figure 10, the cost margin between diesel and natural gas is likely to be maintained throughout the foreseeable future.

However, significant hurdles exist in terms of refueling infrastructure and improvements in LNG engine technology. LNG as a fuel is best suited to high horsepower fleet vehicles with a

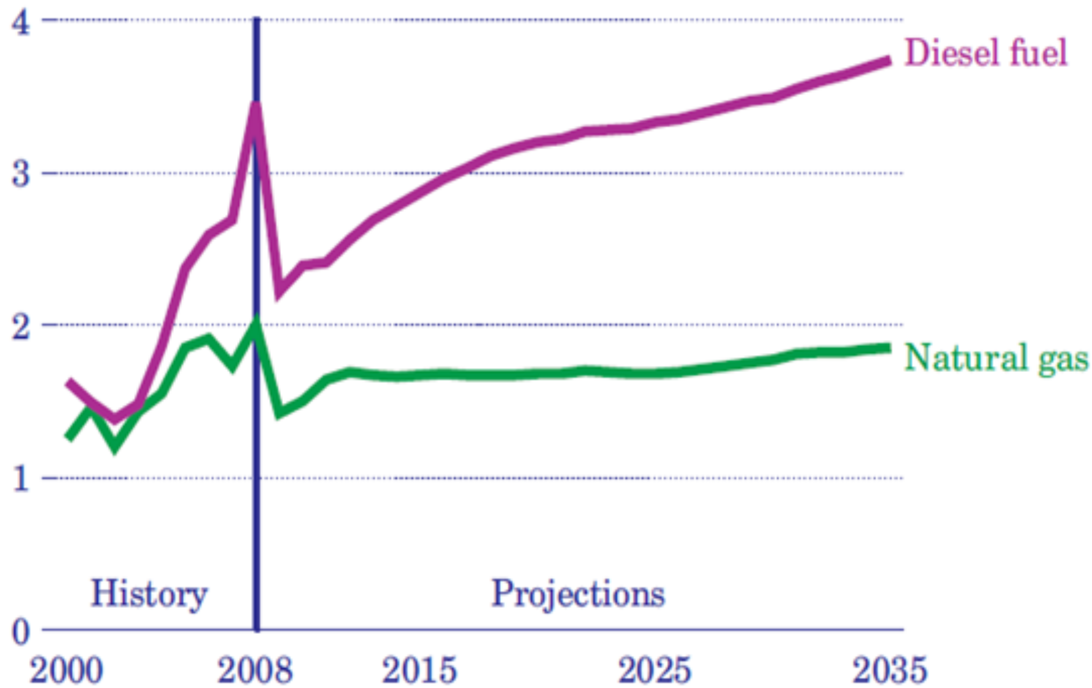

Figure 10. EIA Projected Diesel Natural Gas Cost Differential
Source: EIA Annual Energy Outlook 2010

[43] U.S. Energy Information Administration, "Weekly Fuel Prices," http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMD_EPD2D_PTE_NUS_DPG&f=W, November 2010, (accessed November 6, 2010).

regular turnover of fuel. Regular fuel turnover is needed to prevent the LNG in liquid form from vaporizing. At normal temperatures and pressures, LNG would be in the gaseous state. However, LNG is refrigerated to roughly -270^{o}F and roughly 5 psig (pounds per square inch gauge pressure) where it is a liquid. Warming of the LNG is minimized by the use of insulation in fuel storage where a well-designed system is capable of minimizing liquid boil-off.

CNG (Compressed Natural Gas) is another potential transportation fuel. As shown in Table 3, many countries have significant numbers of CNG vehicles due to the high cost of other transportation fuels.

Table 3. Natural Gas Vehicles Worldwide[44]

Locations	Approximate Number of CNG Vehicles
Pakistan	2,300,000
Argentina	1,807,186
Iran	1,665,602
Brazil	1,632,101
India	935,000
China	450,000
Colombia	300,000
Ukraine	200,000
Bangladesh	177,555
Bolivia	121,908
Egypt	119,679
USA	110,000
Russia	100,000
Venezuela	15,000
Canada	12,000

[44] International Association for Natural Gas Vehicles, "Gas Vehicles Report," http://www.iangv.org/tools-resources/statistics.html, 2009, (accessed November 6, 2010).

One of the biggest impediments to CNG use in the U.S. has been the development of refueling infrastructure. It is difficult if not impossible to travel portions of the U.S. Interstate system with a CNG vehicle due to the lack of refueling stations. CNG is compressed to 3,600 psig for light duty vehicle use. The high pressure gas is stored in specially designed gas cylinders on the vehicle. Due to the size of the storage cylinders and relatively low energy density, CNG is targeted to light duty vehicles such as passenger cars, SUVs, and pickup trucks.

CARBON FOOTPRINT

In terms of carbon footprint, natural gas has the smallest carbon footprint of all fossil fuels. As noted previously, coal has a considerable cost advantage over natural gas but has the worst carbon footprint of the hydrocarbon fuels. Although India and China plan to expand their electricity generation with coal-fired plants, there is an opportunity in the U.S. to displace the use of coal in electrical generation. Table 4 depicts on a common basis, the cost of a kw-hr of electricity for different sources based on 2005 costs.

Table 4. Levelized Cost of Electricity (2005 $/kw-hr)[45]

Energy Source	Reference	Sensitivity
Coal	5.4	
Advanced Natural Gas (NGCC)	5.6	
Advanced Nuclear	8.8	7.3
Coal/Gas with CCS	9.2/8.5	6.9/6.6
Renewables		
Wind	6.0	
Biomass	8.5	
Solar	19.3	
Substitution elasticity (Wind, Biomass, Solar)	1.0	
Wind + Gas Backup	10.0	

[45] MIT, "The Future of Natural Gas," http://web.mit.edu/mitei/research/studies/report-natural-gas.pdf, 2010, p. 22, (accessed November 6, 2010).

COMMODITY PRICING

One of the goals of this thesis is to determine how speculation may be driving prices in the energy markets.

Supply and demand ultimately determines the price of a commodity but recently, the impact of speculation has been singled out as an important factor in the determination of market pricing. Speculation was pointed to as a possible factor in the run-up of crude to $145 per barrel. Commodity speculation is also being pointed to as a contributor to increases in food prices as shown in Figure 11.

The Institute for Agriculture and Food Policy released a report that cited commodity speculation as a contributor to food price volatility and a risk to developing countries' stability (see Figure 11). Rapidly escalating commodity food prices will seriously impact the poor in third world and developing countries.

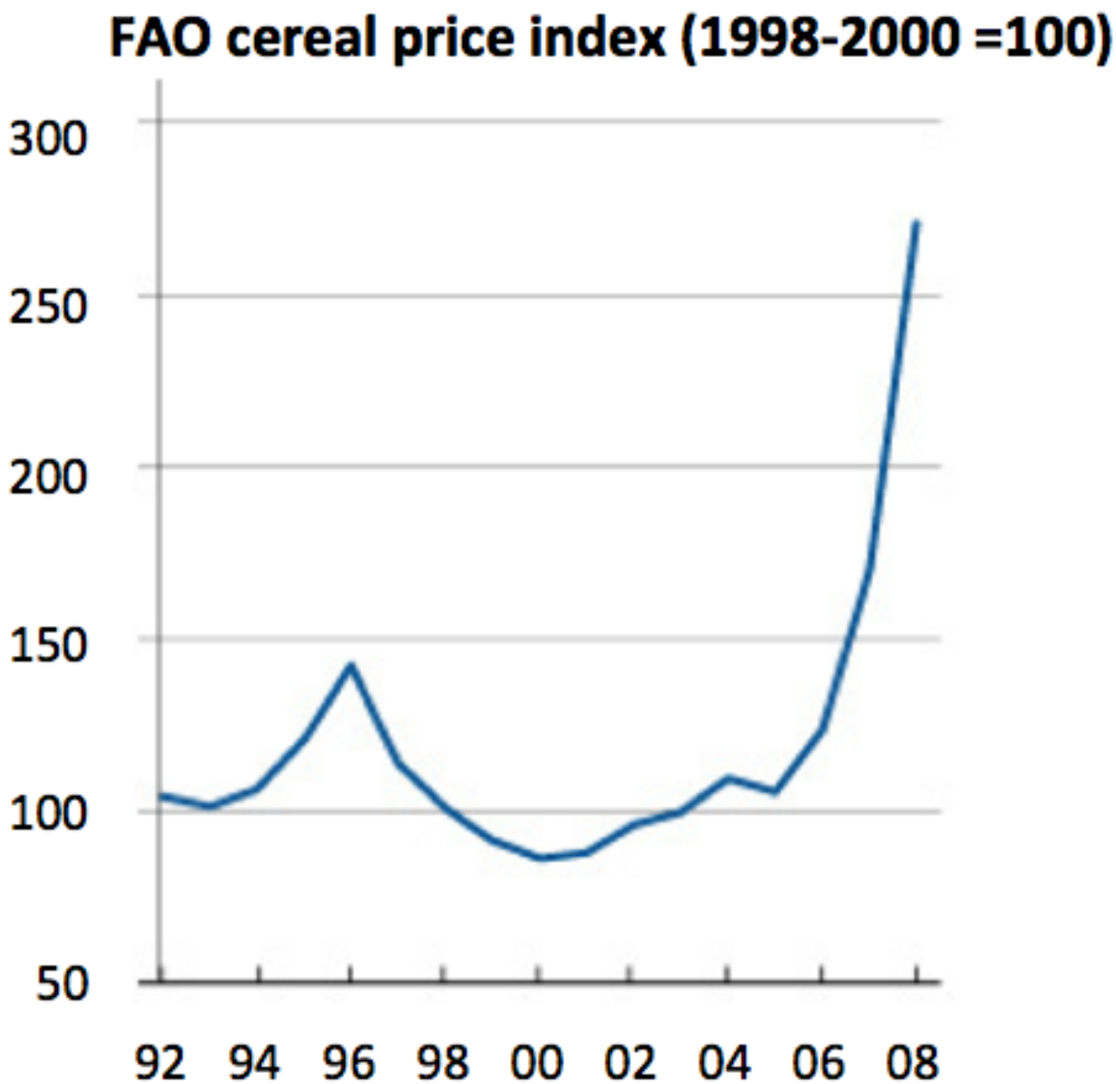

Figure 11. Food and Agriculture Association Cereal Price Index[46]

[46]Institute for Agriculture and Trade Policy, "Commodities Market Speculation: The Risk to Food Security and Agriculture," http://www.iatp.org/tradeobservatory/library.cfm?refID=104414, 2010, p. 3, (accessed November 6, 2010).

ECONOMETRIC MODELS

Trading in the energy markets has been analyzed by a number of researchers with the results being inconclusive. However, Dale and Zyren performed an analysis of the energy markets that concluded that noncommercial traders are likely to switch between markets and add to "hot money" flows.[47] The hypothesis put forth by Dale and Zygren was "do large noncommercial traders tend to concentrate in a single market or do they shift large sums between different markets at the first sign of a possible higher rate of return?"[48]

Daily data were collected from a number of sources and then summarized in a weekly format for analysis using STATA and various ARIMA (Auto Regressive Integrated Moving Average) and VAR (Vector Auto Regression) time series models.

The following definitions are for the various futures contracts downloaded and analyzed from the CFTC weekly historical reports.[49] The U.S. natural gas markets were selected for investigation due to the lack of influence from gas supplies outside the U.S. Unlike crude markets, the natural gas supply to the U.S. is predominantly from domestic sources and Canada. One of the goals of the econometric analysis was to determine the impact of "hot money" on commodity prices.

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47 Charles Dale, John Zygren, "Noncommercial Trading in the Energy Futures Market," Energy Information Administration, Petroleum Marketing Monthly (May1996), p. xiii.
48 Charles Dale, John Zygren, "Noncommercial Trading in the Energy Futures Market," p. 18.
49 U.S. Commodity Trading Futures Commission, Historical Reports, http://www.cftc.gov/MarketReports/CommitmentsofTraders/HistoricalCompressed/index.htm, (accessed November 24, 2010).

Commercial Traders[50]

Commercials are associated with an underlying cash-related business. They are commonly considered to be hedgers. Commercials normally own or anticipate owning the physical product and may use the markets for "hedging" to take an offsetting position in the futures market in an attempt to lock in a cost or profit margin.[51]

Noncommercial Traders[52]

Noncommercials are not involved in an underlying cash business; thus, they are referred to as speculators. Furthermore, reporting level noncommercial activity is generally considered to be that of managed futures or commodity funds. (Commodity pools and hedge funds)

Futures Open Interest

Futures Open Interest is the total number of contracts outstanding, which includes all long, short, and spreading contracts.

Futures Commercial Short Contracts

Futures Commercial Short Contracts are contracts to "sell" the underlying commodity at a future date.

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[50] Dwight R. Sanders, Keith Boris, Mark Manfred, "Hedgers, funds, and small speculators in the energy futures markets: an analysis of the CFTC's Commitments of Traders reports," Energy Economics Volume 26, Issue 3 (May 2004), p. 426.
[51] Charles Dale and John Zygren, "Noncommercial Trading in the Energy Futures Market," Energy Information Administration, Petroleum Marketing Monthly (May1996), p. xvii.
[52] Dwight R. Sanders Keith Boris, Mark Manfred, "Hedgers, funds, and small speculators in the energy futures markets: an analysis of the CFTC's Commitments of Traders reports," 2004, p. 426.

Futures Noncommercial Short Contracts

Noncommercial Short Contracts are futures contracts to "sell" the underlying commodity at a future date.

Futures Commercial Long Contracts

Futures Commercial Long Contracts are futures contracts to purchase the underlying commodity at a future date.

Futures Noncommercial Long Contracts

Noncommercial Long Contracts are futures contracts to purchase the underlying commodity at a future date.

Table 5 summarizes the key variables in the econometric analysis.

Table 5. Summary Statistics of Key Variables

Name	Label	Mean	Standard Dev.	Min	Max
real_gas_price	Real natural gas price in 2010 dollars	5.499106	2.749613	2.077087	17.06117
futures_open_interest	Natural gas futures contracts open interest.	447396.6	254039.3	110254	971774
ln_real_ng_price	Natural log of real natural gas prices	1.590061	.474485	.7309664	2.836805
ln_open_interest	Natural log of futures contract open interest	12.83409	.617185	11.61054	13.78688
futures_com_short	Natural gas futures commercial short contracts	238825.6	97523.88	83355	477839
futures_non_short	Natural gas futures noncommercial short contracts	72613.33	89716.68	915	396198
futures_com_long	Natural gas futures commercial long contracts	240918.1	106063.1	72102	458476
futures_non_long	Natural gas futures noncommercial long contracts	45926.31	44583.15	3255	220973

TIME SERIES ANALYSIS

ARIMA (Autoregression Integrated Moving Average), ARCH (Autoregression Constant Heteroskedasticity), and VAR (Vector Autoregression) models offer different techniques for analyzing the natural gas data. Of the three methods of time series analysis, the VAR is superior due to the nonstationarity and heteroskedasticity in the natural gas data.

There were six VAR models analyzed using STATA 10 software that were of particular interest:

1. Natural Gas Prices and Commercial Futures Open Interest (Figure 12)
2. Log Natural Gas Prices and Log of Futures Open Interest (Figure 13)
3. Natural Gas Prices and Commercial Futures Short Contracts (Figure 14)
4. Natural Gas Prices and Noncommercial Futures Short Contracts (Figure 15)
5. Natural Gas Prices and Commercial Futures Contracts (Figure 16)
6. Natural Gas Prices and Noncommercial Long Futures Contracts (Figure 17)

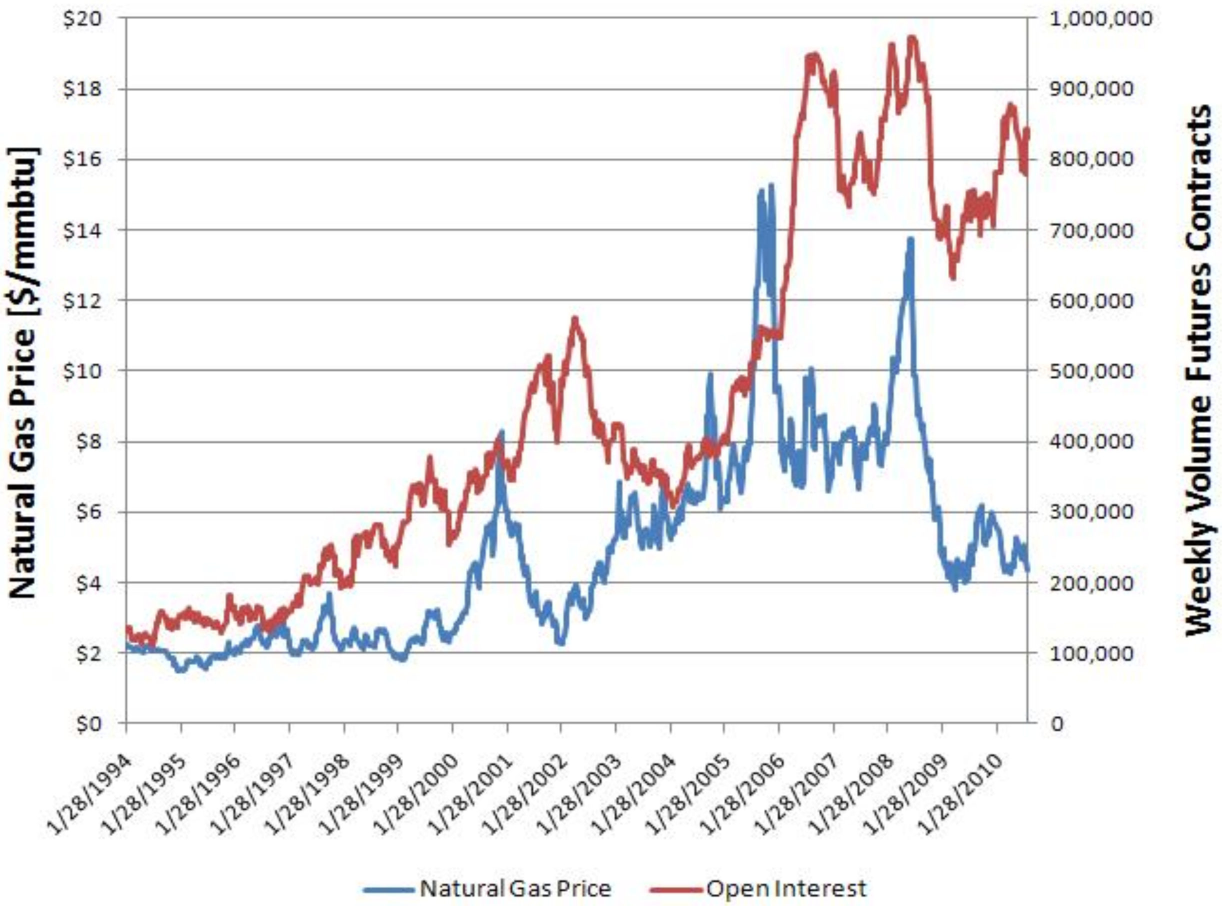

Figure 12. Natural Gas Prices and Commercial Futures Open Interest

MODEL 1. Stata command: var real_gas_price futures_open_interest

$$real\_gas\_price_t = 1.20279\ real\_gas\_price_{t-1} - 0.2248819\ real\_gas\_price_{t-2} + 2.24e\text{-}06\ futures\_open\_interest_{t-1} - 2.14e\text{-}06\ futures\_open\_interest_{t-2} + 0.0710576$$

$$futures\_open\_interest_t = 1.150931\ futures\_open\_interest_{t-1} - 0.1529734\ futures\_open\_interest_{t-2} + 931.6411$$

All coefficients are significant at the 95% confidence level with the exception of the coefficients for real_gas_price $_{t-1}$ and real_gas_price $_{t-2}$ in the second vector equation.

Granger causation testing determined that futures open interest Granger-causes real natural gas prices. This result implies that as increasing contracts (open interest) in the futures market serves to drive natural gas prices in real terms.

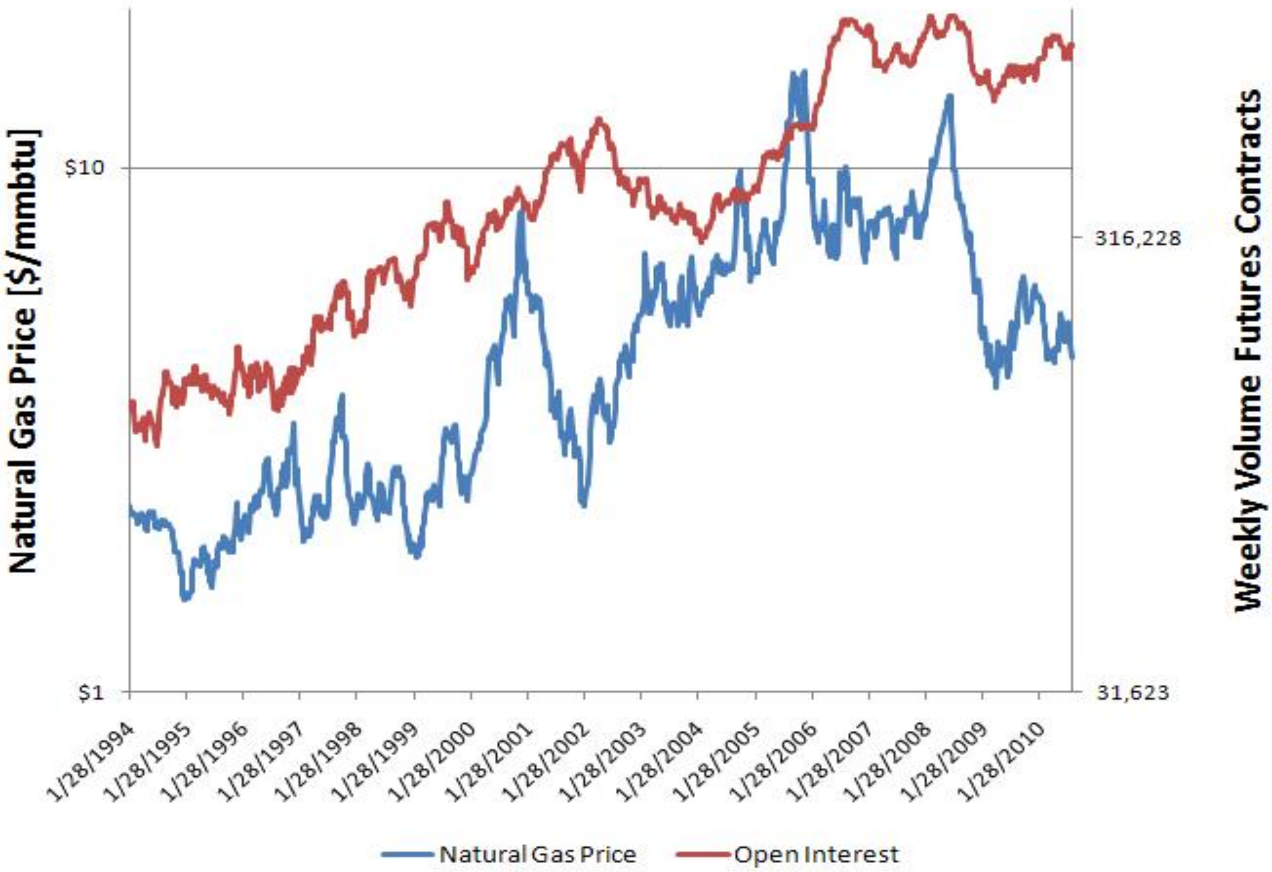

Figure 13. Log Natural Gas Prices and Log of Futures Open Interest

MODEL 2. Stata command: var ln_real_ng_price ln_open_interest

$$\text{ln\_real\_ng\_price}_t = 1.126571\ \text{ln\_real\_ng\_price}_{t-1} - 0.1471069\ \text{ln\_real\_ng\_price}_{t-2} + 0.1478069\ \text{ln\_open\_interest}_{t-1} - 0.1380233\ \text{ln\_open\_interest}_{t-2} - 0.093164$$

$$\text{ln\_real\_ng\_price}_t = 0.034977\ \text{ln\_real\_ng\_price}_{t-1} - 0.0347661\ \text{ln\_real\_ng\_price}_{t-2} + 1.06969\ \text{ln\_open\_interest}_{t-1} - 0.0722524\ \text{ln\_open\_interest}_{t-2} + 0.0345122$$

All coefficients are significant at the 95% confidence level.

Granger causation testing determined that changes in futures open interest Granger-causes changes in real natural gas prices. This result implies that changes in futures contracts (open interest) help drive changes in natural gas prices in real terms.

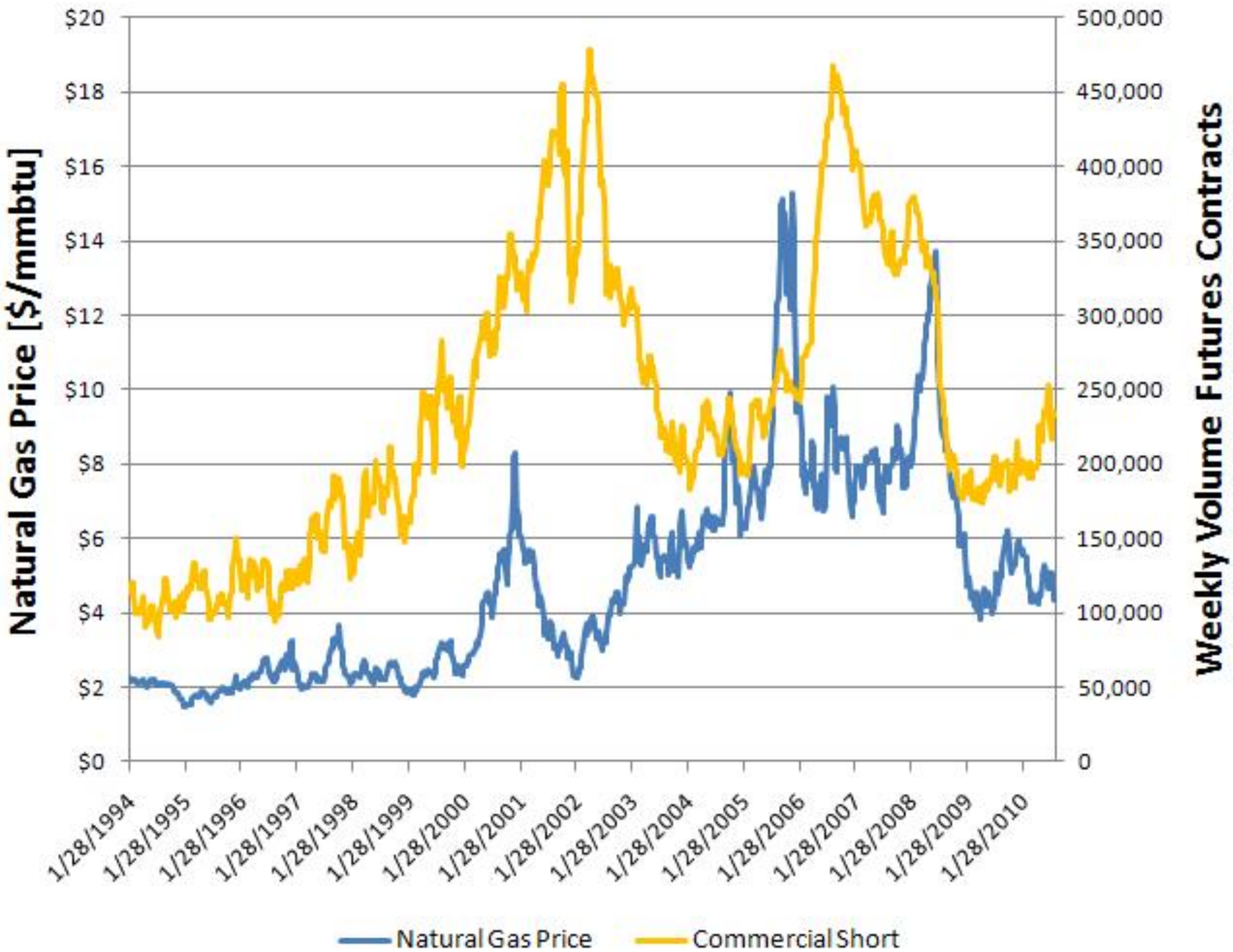

Figure 14. Natural Gas Prices and Commercial Futures Short Contracts

MODEL 3. Stata command: var real_gas_price futures_com_short

$$real\_gas\_price_t = 1.200636\, real\_gas\_price_{t-1} - 0.2225302\, real\_gas\_price_{t-2} + 0.0398491$$

$$futures\_com\_short_t = 3349.771\, real\_gas\_price_{t-1} - 3475.84\, real\_gas\_price_{t-2} + 1.158688\, futures\_com\_short_{t-1} - 0.163795\, futures\_com\_short_{t-2} + 2023.924$$

All coefficients are significant at the 95% confidence level with the exception of the coefficients for $futures\_com\_short_{t-1}$ and $futures\_com\_short_{t-2}$ in the first vector equation.

Granger causation testing determined that real natural gas prices Granger-causes futures commercial short positions. This result implies that real natural gas prices drive short commercial futures contracts.

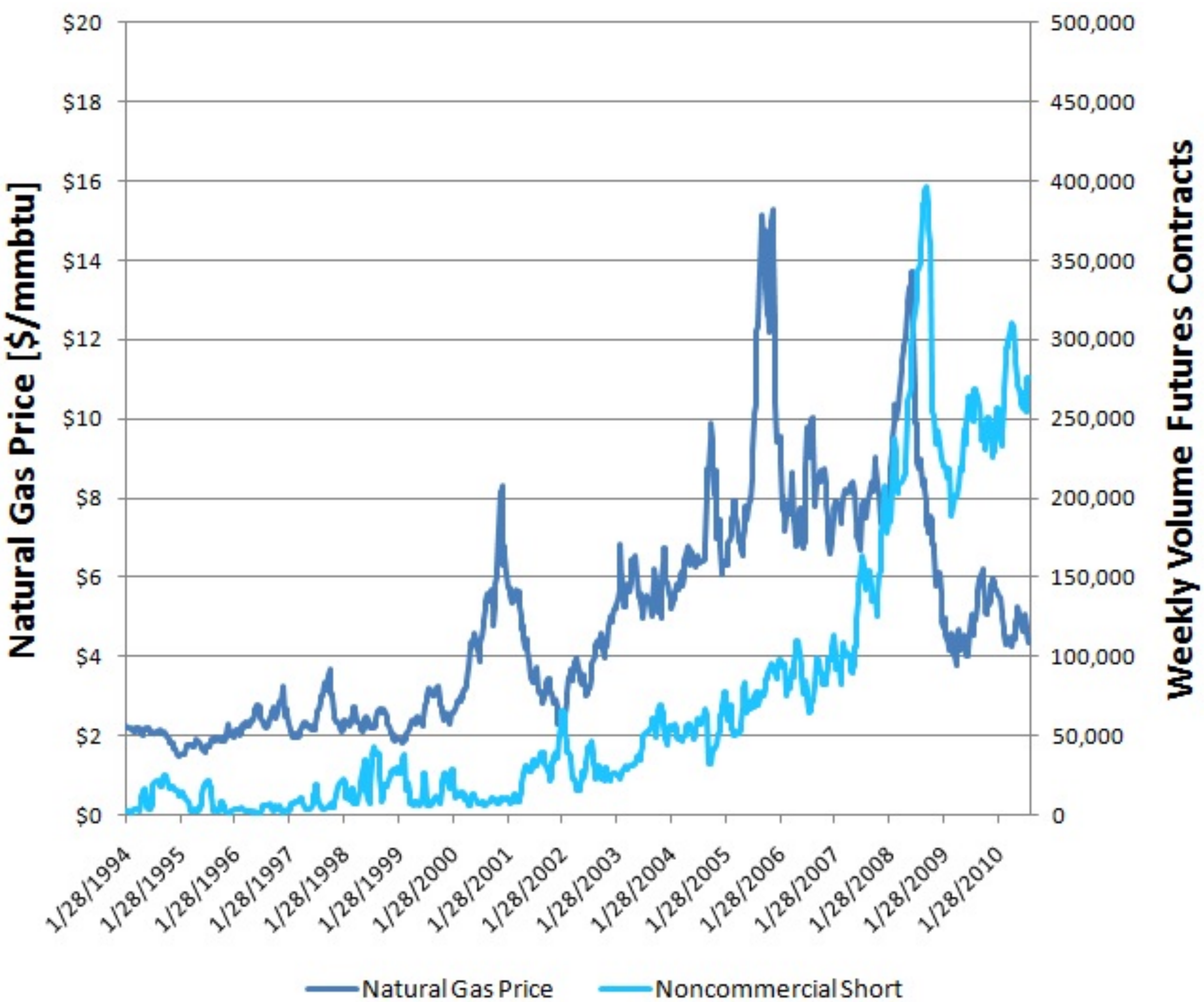

Figure 15. Natural Gas Prices and Noncommercial Futures Short Contracts

MODEL 4. Stata command: var real_gas_price futures_non_short

$$real\_gas\_price_t = 1.210243\ real\_gas\_price_{t-1} - 0.2273802 real\_gas\_price_{t-2} + 0.0908204$$

$$futures\_non\_short_t = -1881.614\ real\_gas\_price_{t-1} + 2093.16\ real\_gas\_price_{t-2} + 1.273068\ futures\_non\_short_{t-1} - 0.277184\ futures\_non\_short_{t-2} - 635.4323$$

All coefficients are significant at the 95% confidence level with the exception of the coefficients for $futures\_non\_short_{t-1}$ and $futures\_non\_short_{t-2}$ in the first vector equation.

Granger causation testing determined that real natural gas prices Granger-causes futures noncommercial short positions. This result implies that natural gas prices in real terms drive futures noncommercial short contracts.

Figure 16. Natural Gas Prices and Commercial Futures Contracts

MODEL 5. Stata command: var real_gas_price futures_com_long

$$real\_gas\_price_t = 1.20581\ real\_gas\_price_{t-1} - 0.2259098\ real\_gas\_price_{t-2} + 0.055533$$

$$futures\_com\_long_t = -1743.704\ real\_gas\_price_{t-1} + 1840.089\ real\_gas\_price_{t-2} + 1.099782\ futures\_com\_long_{t-1} - 0.1054234\ futures\_com\_long_{t-2} + 1110.08$$

All coefficients are significant at the 95% confidence level with the exception of the coefficients for futures_com_long $_{t-1}$ and futures_com_long $_{t-2}$ in the first vector equation.

Granger causation testing determined that real natural gas prices Granger-causes futures commercial long positions. This result implies that natural gas prices in real terms drive futures commercial long contracts.

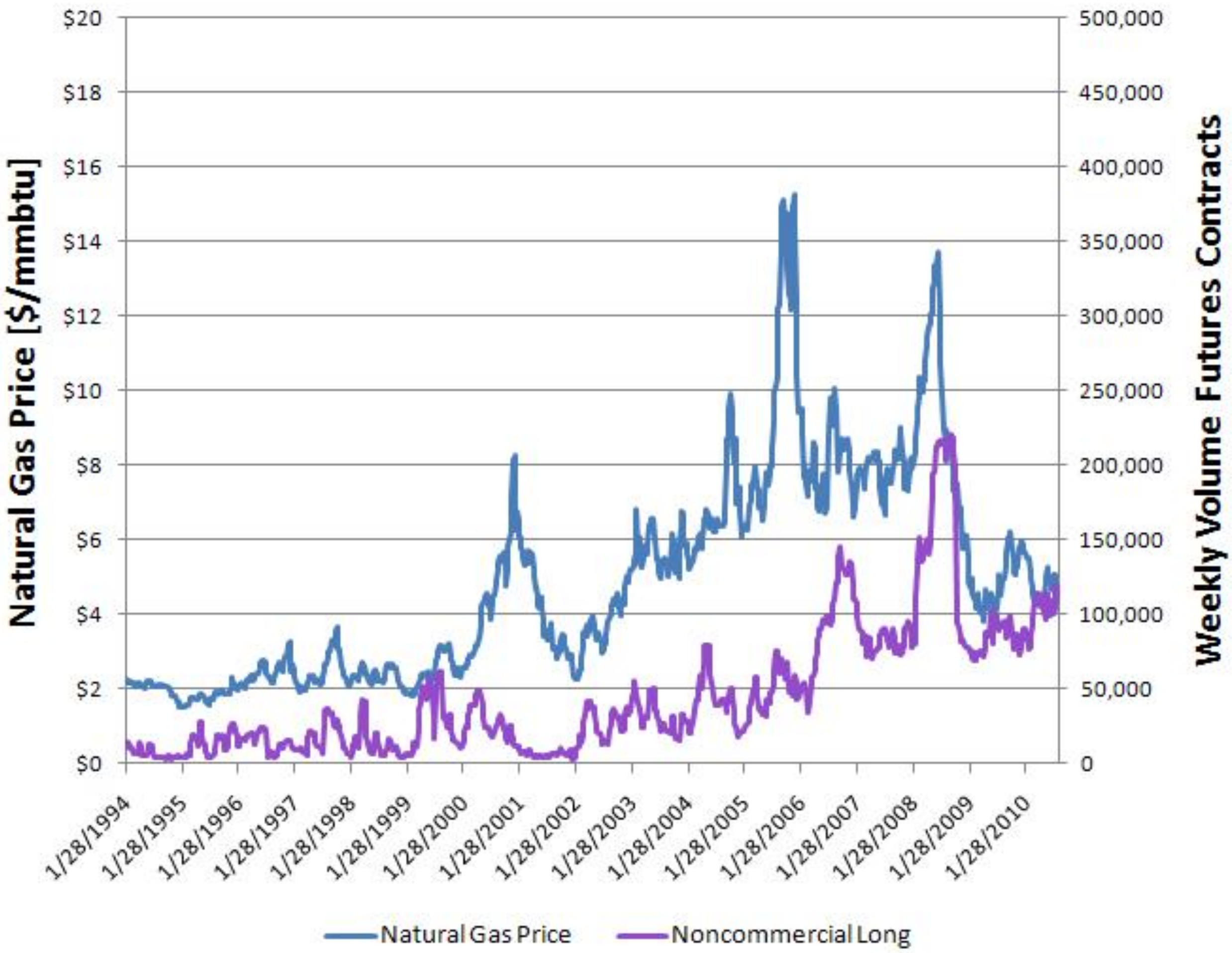

Figure 17. Natural Gas Prices and Noncommercial Long Futures Contracts

MODEL 6. Stata command: var real_gas_price futures_non_long

$$real\_gas\_price_t = 1.204946\ real\_gas\_price_{t-1} - 0.2248425\ real\_gas\_price_{t-2} + 2.59e{-}07\ futures\_non\_long_{t-1} + 1.59e{-}07\ futures\_non\_long_{t-2} + 0\ .0904125$$

$$futures\_non\_long_t = 2153.853\ real\_gas\_price_{t-1} - 2059.336\ real\_gas\_price_{t-2} + 1.19518 futures\_non\_long_{t-1} - 0.2084536\ futures\_non\_long_{t-2} + 175.5243$$

All coefficients are significant at the 95% confidence level with the exception of the coefficients for $futures\_non\_long_{t-1}$ and $futures\_non\_long_{t-2}$ in the first vector equation.

Granger causation testing determined that real natural gas prices Granger-causes futures noncommercial long positions. This result implies that natural gas prices in real terms drive futures noncommercial long contracts.

ECONOMETRIC RESULTS

The econometric analysis determined that there is an influence of futures contracts on natural gas prices in real and nominal terms.

- Futures open interest Granger-causes natural gas prices (in both real and nominal terms).
- Changes in open interest Granger-causes changes in natural gas prices (in both real and nominal terms).
- Real natural gas prices Granger-causes futures commercial short positions.
- Real natural gas prices Granger-causes futures noncommercial short positions.
- Real natural gas prices Granger-causes futures commercial long positions.
- Real natural gas prices Granger-causes futures noncommercial long positions.

Speculation in the form of futures open interest is driving prices in the natural gas markets. Furthermore, prices are attracting commercial and noncommercial participants to the natural gas futures market.

ECONOMETRIC SUMMARY OF ACADEMIC PAPERS

The following summarizes academic papers that have evaluated the impact of speculation on futures markets.

Noncommercial Trading in the Energy Futures Markets

by Charles Dale and John Zyren

The general model used for the investigation

$\Delta C_t = f(\Delta P_{t,} \Delta P_{wti,} \Delta P_{tb,} \Delta CN_{j)}$

where:

C_t represents the number of contracts (long or short) of noncommercial traders.

P_t is the "nearby," i.e., next expiring futures contract price.

P_{wti} is the nearby crude oil futures contract price.

P_{tb} is the nearby Treasury bond futures contract price.

CN_j represents the net positions of related futures contracts.[53]

Summary Results

First, there were statistically significant positive coefficients for every "nearby," i.e., next expiring, futures contract price in the regression for the number of long holdings for that

[53] Charles Dale, John Zyren, "Noncommercial Trading in the Energy Futures Market," Energy Information Administration, Petroleum Marketing Monthly (May1996), p. xx.

contract, e.g., a price increase of crude oil led to an increase in long crude oil contract holdings. Similarly, there were statistically significant negative coefficients for prices that correspond to short holdings, e.g., a price increase of crude oil led to a decrease in short crude oil contract holdings. These results mean that in the same weekly period, a price rise in nearby futures contracts is associated with a purchase of additional long contracts and a selling of short contracts. This contemporaneous correlation strongly suggests that energy traders follow price trends, they do not set them. They buy on price rallies and sell into price dips.[54]

Markets for Crude Oil, Gasoline, Heating Oil, and Treasury Bonds were analyzed. Natural gas markets in the time period of the data (October 6, 1992 through June 27, 1995) were NOT analyzed.

Devil or Angel? The Role of Speculation in the Recent Commodity Price Boom (and Bust) by Scott H. Irwin, Dwight R. Sanders, and Robert P. Merrin

Standard Granger causality tests between futures price changes and position changes in commodity futures markets were carried out. These tests establish whether lagged position changes help to forecast current futures price changes.[55]

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[54] Charles Dale, John Zyren, "Noncommercial Trading in the Energy Futures Market," Energy Information Administration, Petroleum Marketing Monthly (May1996), p. xx.
[55] Dwight R. Sanders, Scott H. Irwin, Robert P. Merrin, "Devil or Angel? The Role of Speculation in the Recent Commodity Price Boom and Bust," Journal of Agricultural and Applied Economics, 41, 2, (August 2009), p. 386.

Summary Results

A statistically significant relationship between the movement of commodity futures prices and measures of position change is found in only 5 out of 30 cases.

Wheat, corn, soybeans, hogs, and cattle markets were empirically analyzed. Energy markets were NOT analyzed.

Hedgers, Funds, and Small Speculators in the Energy Futures Markets:

an Analysis of the CFTC/s Commitments of Traders Reports

by Dwight R. Sanders, Keith Boris, and Mark Manfredo

There were three models that were used to analyze the data.

$PNL_t = \varphi + \Sigma\ \lambda_i PNL_{t-1} + \Sigma\ \theta_j R_{t-j} + \omega_t$ – *Do returns lead traders' positions?*

$R_t = \alpha + \Sigma\ \gamma_i R_{t-1} + \Sigma\ \beta_j PNL_{t-j} + \varepsilon_t$ – *Do traders' positions lead returns?*

$R_t = \alpha_0 + \alpha_1 LO_{t-1} + \alpha_2 HI_{t-1} + \varepsilon_t$ - *Impact of extreme trader positions*

where:

PNL is defines as present net long positions (Long – Short)/(Long + Short)

R is defines as market returns

LO is defined as a variable where LO=1 if PNL is in the lower 20^{th} percentile of its range from the prior 3 years, and LO=0 otherwise.

HI is defined as a variable where HI=1 if PNL is in the upper 20^{th} percentile of its range from the prior 3 years, and HI=0 otherwise.

Summary Results

The results indicate that reporting noncommercials increase their long positions in rising markets, and commercials decrease their positions in rising markets. Positive futures returns Granger cause increases in the net long positions held by reporting noncommercial traders, whereas commercials are net sellers following price increases. Commercials are net sellers the week following an increase in prices, and noncommercials are net buyers.[56]

The time period analyzed was from October 1992 to December 1999. Energy markets for Crude Oil, Gasoline, Heating Oil, and Natural Gas were analyzed.

A Speculative Bubble in Commodity Futures Prices? Cross-Sectional Evidence

by Dwight R. Sanders, Scott H. Irwin, and Robert P. Merrin

There were three models that were used to analyze the data.

$R_{i,t+1} = \alpha + \beta Positions_{i,t} + e_t$

$R_{i,t+1} = \alpha + \beta Positions_{i,t} + \Theta R_t + e_t$

where:

$Positions_{i,t}$ is defines as an index fund position at time t

R is defines as market returns

[56] Dwight R. Sanders, Scott H. Irwin, Robert P. Merrin, "Devil or Angel? The Role of Speculation in the Recent Commodity Price Boom and Bust," Journal of Agricultural and Applied Economics, 41, 2, (August 2009), p. 443.

Summary Results

The evidence that index fund positions impact returns across markets is scant. Similarly, the vast majority of empirical evidence presented by academic researchers fails to find any relationship between positions held by large traders and subsequent price behavior.[57]

Twelve agricultural futures markets were analyzed based on data from the CIT (Commodity Index Traders) report from the CFTC (Commodity Futures Trading Commission) from January 3, 2006 through December 30, 2008. The markets in the analysis were: corn, soybeans, soybean oil, COBT (Chicago Board of Trade) wheat, KCBOT (Kansas City Board of Trade) wheat, cotton, live cattle, feeder cattle, lean hogs, coffee, sugar, and cocoa.

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[57] Dwight R. Sanders, Scott H. Irwin, Robert P. Merrin, "A Speculative Bubble in Commodity Futures Prices? Cross-Sectional Evidence," (Paper presented at the NCCC-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management St. Louis, Missouri, April 20-21, 2009), p. 8.

CONCLUSION

As noted in the thesis, world energy surpluses are dwindling, and the demand projections for emerging markets are projected to overwhelm Middle East supplies by as early as 2015. The 2007 economic crisis has pushed back investment in energy projects where a low-growth scenario in world GDP could create drastic price increases in world energy prices. Without a long-term energy supply plan, the U.S. is destined to see growth reduced and its trade imbalances continue to deteriorate with increasing energy costs.

Based on the economic models presented in this paper, speculation adds to price movements in the energy markets, which in the short term could cause violent swings in energy prices.

Recent improvements in the production of unconventional natural gas supplies have increased the country's reserves where opportunities exist to reduce the dependence on foreign petroleum supplies. The primary areas where natural gas could make a contribution to U.S. energy imbalance would be in electricity generation and transportation fuels. India and China have committed to increases in electrical production via coal, which could lead to the export of U.S. coal to those markets. The void left in U.S. electricity production could easily be met by natural gas. In addition to the electrical market, natural gas as a transportation fuel could also stabilize U.S. energy supplies if trucking, shipping, and rail were to embrace natural gas. The U.S. government, in particular the U.S. military, could have a major impact on domestic energy markets if it were to utilize domestic natural gas supplies in place of foreign supplies.

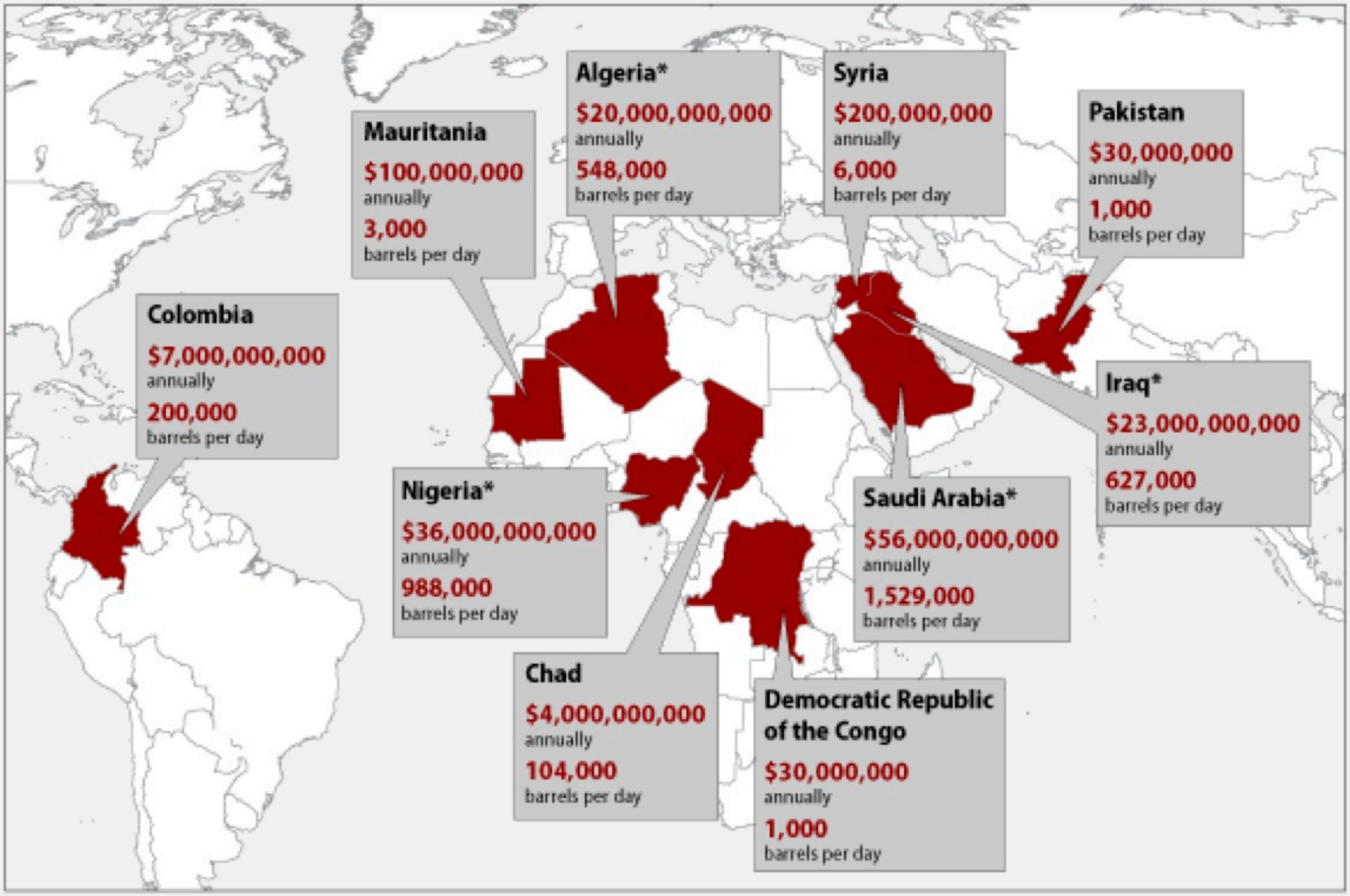
One in five barrels of U.S. oil is derived from a country that the State Department views to be "dangerous or unstable" (see Figure 18). The cost of this oil is volatile and can be cut off at any time,[58] which would pose a serious economic shock to the U.S. In 2008 the ten countries that the U.S. imported oil from and considered unstable were Columbia, Mauritania, Algeria, Syria, Pakistan, Iraq, Saudi Arabia, Democratic Republic of the Congo, Chad, and Nigeria.[59]

Without a comprehensive energy policy, the U.S. is dependent on energy free markets to supply its needs. As this paper pointed out, the future energy markets are likely to see greater volatility and increased completion by developing countries such as China and India. In contrast to the free market approach taken in the U.S., Chinese oil companies have chosen to pursue reserves on numerous continents. China is in the midst of an internal debate, which involves its military, over how to ensure the county's oil needs are met without undermining national security.[60]

Now that the supply surpluses in the energy markets have disappeared, there could be wild swings ahead in the energy markets that will undermine recovery from the 2007 financial crisis as well as compromise future economic growth. The U.S. is at risk for its national security and economic future if it does not establish a comprehensive energy policy.

---

[58] Alexander Smith, "Oil is Spiking – Are you positioned?" Seeking Alpha, http://seekingalpha.com/article/228660-oil-is-spiking-are-you-positioned?source=feed, (accessed October 31, 2010).
[59] Rebecca Lefton and Daniel J. Weiss, Center for American Progress, "Oil Dependence Is a Dangerous Habit," http://www.americanprogress.org/issues/2010/01/oil_imports_security.html, December 2010, (accessed December 14, 2010).12
[60] Erica S. Downs, "The Chinese Energy Security Debate," The China Quarterly, No. 177 (March 2004), p. 21.



Source: U.S. Energy Information Administration, "Company Level Imports Historical," available at http://www.eia.doe.gov/oil_gas/petroleum /data_publications/company_level_imports/cli_historical.html.

Figure 18. 2008 Crude Oil Imports from Unstable Countries

APPENDIX A

STATA LOG FILE

```
/// Summary Statistics of Key Variables
> summarize real_gas_price  futures_open_interest ln_real_ng_price ln_open_interest ///
>           futures_com_short futures_non_short futures_com_long futures_non_long
```

Variable	Obs	Mean	Std. Dev.	Min	Max
real_gas_p~e	866	5.499106	2.749613	2.077087	17.06117
futures_op~t	866	447396.6	254039.3	110254	971774
ln_real_ng~e	866	1.590061	.474485	.7309664	2.836805
ln_open_in~t	866	12.83409	.617185	11.61054	13.78688
futures_co~t	866	238825.6	97523.88	83355	477839
futures_no~t	866	72613.33	89716.68	915	396198
futures_co~g	866	240918.1	106063.1	72102	458476
futures_no~g	866	45926.31	44583.15	3255	220973

```
Vector autoregression
> var  real_gas_price futures_open_interest
```

```
Sample:  3 - 866                        No. of obs      =      864
Log likelihood =  -9950.31                  AIC           =  23.05627
FPE          =  3.53e+07                  HQIC          =  23.07737
Det(Sigma_ml)  =  3.45e+07                   SBIC          =  23.11138
```

Equation	Parms	RMSE	R-sq	chi2	P>chi2
real_gas_price	5	.435943	0.9750	33718.48	0.0000
futures_open_i~t	5	13558.1	0.9972	303494.1	0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]

```
real_gas_p~e |
real_gas_p~e |
       L1. |    1.20279   .0330789    36.36   0.000     1.137956    1.267623
       L2. |  -.2248819   .0331323    -6.79   0.000      -.28982   -.1599438
futures_op~t |
       L1. |   2.24e-06   1.08e-06     2.08   0.038     1.28e-07    4.36e-06
       L2. |  -2.14e-06   1.08e-06    -1.98   0.048    -4.25e-06   -1.80e-08
     _cons |   .0710576   .0350632     2.03   0.043      .002335    .1397801
-------------+----------------------------------------------------------------
futures_op~t |
real_gas_p~e |
L1. |   1829.388   1028.777     1.78   0.075    -186.9777    3845.754
       L2. |  -1709.183   1030.438    -1.66   0.097    -3728.804     310.438
futures_op~t |
       L1. |   1.150931    .033586    34.27   0.000     1.085104    1.216759
       L2. |  -.1529734   .0335965    -4.55   0.000    -.2188213   -.0871256
     _cons |   931.6411   1090.489     0.85   0.393    -1205.679    3068.961
------------------------------------------------------------------------------

. vargranger

  Granger causality Wald tests
 +------------------------------------------------------------------+
 |          Equation           Excluded |   chi2     df Prob > chi2 |
 |--------------------------------------+---------------------------|
 |    real_gas_price  futures_open_in~t |  6.5436     2    0.038    |
 |    real_gas_price                ALL |  6.5436     2    0.038    |
 |--------------------------------------+---------------------------|
 | futures_open_in~t     real_gas_price |  3.3504     2    0.187    |
 | futures_open_in~t                ALL |  3.3504     2    0.187    |
 +------------------------------------------------------------------+

.
. var ln_real_ng_price  ln_open_interest

Vector autoregression

Sample:  3 - 866                           No. of obs      =       864
Log likelihood =  2762.098                 AIC             = -6.370597
FPE            =  5.87e-06                 HQIC            = -6.349503
Det(Sigma_ml)  =  5.73e-06                 SBIC            = -6.315486

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
```

```
ln_real_ng_price     5     .067937   0.9796   41549.86   0.0000
ln_open_interest     5     .03553   0.9967   259921.7   0.0000
------------------------------------------------------------
--------------------------------------------------------------------------
           |     Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+------------------------------------------------------------
ln_real_ng~e |
ln_real_ng~e |
       L1. |   1.126571   .0336573    33.47   0.000     1.060604    1.192538
       L2. |  -.1471069   .0336764    -4.37   0.000    -.2131115   -.0811023
ln_open_in~t |
       L1. |   .1478069     .06494     2.28   0.023     .0205268    .2750871
       L2. |  -.1380233   .0649414    -2.13   0.034    -.2653061   -.0107405
     _cons |    -.093164   .0583009    -1.60   0.110    -.2074316    .0211037
-------------+------------------------------------------------------------
ln_open_in~t |
ln_real_ng~e |
       L1. |    .034977   .0176024     1.99   0.047     .0004768    .0694771
       L2. |  -.0347661   .0176125    -1.97   0.048     -.069286   -.0002463
ln_open_in~t |
       L1. |    1.06969   .0339631    31.50   0.000     1.003124    1.136257
L2. |  -.0722524   .0339638    -2.13   0.033    -.1388202   -.0056846
     _cons |   .0345122   .0304909     1.13   0.258    -.0252487    .0942732
--------------------------------------------------------------------------
```

. vargranger

```
  Granger causality Wald tests
  +------------------------------------------------------------------+
  |          Equation           Excluded |   chi2     df Prob > chi2 |
  |--------------------------------------+---------------------------|
  |  ln_real_ng_price   ln_open_interest |  8.6143     2    0.013    |
  |  ln_real_ng_price                ALL |  8.6143     2    0.013    |
  |--------------------------------------+---------------------------|
  |  ln_open_interest   ln_real_ng_price |  3.9645     2    0.138    |
  |  ln_open_interest                ALL |  3.9645     2    0.138    |
  +------------------------------------------------------------------+
```

.
. var real_gas_price futures_com_short

Vector autoregression

Sample: 3 - 866   No. of obs   =   864

```
Log likelihood = -9620.346                    AIC            =  22.29247
FPE            =  1.65e+07                    HQIC           =  22.31356
Det(Sigma_ml)  =  1.61e+07                    SBIC           =  22.34758

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
real_gas_price       5     .436602   0.9749   33614.23   0.0000
futures_com_sh~t     5     9262.33   0.9910   95225.77   0.0000
----------------------------------------------------------------
------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
real_gas_p~e |
real_gas_p~e |
         L1. |   1.200636   .0333524    36.00   0.000     1.135267    1.266005
         L2. |  -.2225302   .0333075    -6.68   0.000    -.2878116   -.1572487
futures_co~t |
         L1. |   5.88e-07   1.56e-06     0.38   0.707    -2.48e-06    3.65e-06
         L2. |  -2.50e-07   1.57e-06    -0.16   0.873    -3.32e-06    2.82e-06
       _cons |   .0398491     .04178     0.95   0.340    -.0420382    .1217365
-------------+----------------------------------------------------------------
futures_co~t |
real_gas_p~e |
         L1. |   3349.771   707.5573     4.73   0.000     1962.985    4736.558
         L2. |   -3475.84   706.6053    -4.92   0.000    -4860.761   -2090.919
futures_co~t |
         L1. |   1.158688   .0331852    34.92   0.000     1.093646    1.223729
         L2. |   -.163795   .0332232    -4.93   0.000    -.2289113   -.0986786
       _cons |   2023.924   886.3472     2.28   0.022     286.7158    3761.133
------------------------------------------------------------------------------

. vargranger

   Granger causality Wald tests
  +------------------------------------------------------------------+
  |          Equation           Excluded |   chi2     df Prob > chi2 |
  |--------------------------------------+---------------------------|
  |    real_gas_price  futures_com_short |  3.9194     2    0.141    |
  |    real_gas_price                ALL |  3.9194     2    0.141    |
  |--------------------------------------+---------------------------|
  | futures_com_short     real_gas_price |  24.505     2    0.000    |
  | futures_com_short                ALL |  24.505     2    0.000    |
  +------------------------------------------------------------------+
```

```
. var  real_gas_price  futures_non_short

Vector autoregression

Sample:  3 - 866                          No. of obs     =      864
Log likelihood = -9259.676                   AIC          =  21.45758
FPE          =   7144328                    HQIC         =  21.47868
Det(Sigma_ml)  =   6980847                     SBIC          =  21.51269

Equation          Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
real_gas_price       5     .437255   0.9749   33511.26   0.0000
futures_non_sh~t     5     6101.96   0.9954   186947.6   0.0000
----------------------------------------------------------------
------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
real_gas_p~e |
real_gas_p~e |
          L1. |   1.210243   .0333555    36.28   0.000     1.144867    1.275619
          L2. |  -.2273802   .0334715    -6.79   0.000    -.2929832   -.1617773
futures_no~t |
          L1. |   2.64e-06   2.32e-06     1.14   0.255    -1.91e-06    7.18e-06
          L2. |  -2.60e-06   2.32e-06    -1.12   0.263    -7.14e-06    1.95e-06
       _cons |   .0908204   .0333346     2.72   0.006     .0254858     .156155
-------------+----------------------------------------------------------------
futures_no~t |
real_gas_p~e |
          L1. |  -1881.614   465.4817    -4.04   0.000    -2793.942   -969.2869
          L2. |    2093.16   467.1003     4.48   0.000      1177.66    3008.659
futures_no~t |
          L1. |   1.273068   .0323442    39.36   0.000     1.209675    1.336462
          L2. |   -.277184   .0323705    -8.56   0.000    -.3406289   -.2137391
       _cons |  -635.4323   465.1897    -1.37   0.172    -1547.187    276.3229
------------------------------------------------------------------------------

. vargranger

   Granger causality Wald tests
  +------------------------------------------------------------------+
  |          Equation           Excluded |   chi2     df Prob > chi2 |
  |--------------------------------------+---------------------------|
  |    real_gas_price  futures_non_short |  1.3272     2    0.515    |
  |    real_gas_price                ALL |  1.3272     2    0.515    |
```

```
|------------------------------------+--------------------------|
 | futures_non_short    real_gas_price |   24.74     2    0.000    |
 | futures_non_short              ALL |   24.74     2    0.000    |
 +----------------------------------------------------------------+

.
. var  real_gas_price   futures_com_long

Vector autoregression

Sample:  3 - 866                          No. of obs      =       864
Log likelihood = -9605.735                  AIC            =  22.25865
FPE          =  1.59e+07                  HQIC           =  22.27974
Det(Sigma_ml)  =  1.56e+07                  SBIC           =  22.31376

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
real_gas_price       5     .436878   0.9749   33570.62   0.0000
futures_com_long     5     9086.81   0.9927   117128.3   0.0000
----------------------------------------------------------------
------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
real_gas_p~e |
real_gas_p~e |
         L1. |    1.20581   .0332005    36.32   0.000     1.140738    1.270882
         L2. |  -.2259098   .0331987    -6.80   0.000    -.2909781   -.1608416
futures_co~g |
         L1. |   1.46e-06   1.62e-06     0.90   0.369    -1.72e-06    4.64e-06
         L2. |  -1.23e-06   1.62e-06    -0.76   0.448    -4.41e-06    1.95e-06
       _cons |    .055533   .0404272     1.37   0.170    -.0237028    .1347688
-------------+----------------------------------------------------------------
futures_co~g |
real_gas_p~e |
         L1. |  -1743.704   690.5511    -2.53   0.012     -3097.16   -390.2489
         L2. |   1840.089   690.5139     2.66   0.008     486.7061    3193.471
futures_co~g |
         L1. |   1.099782   .0337299    32.61   0.000     1.033672    1.165891
         L2. |  -.1054234   .0337335    -3.13   0.002    -.1715399   -.0393068
       _cons |    1110.08   840.8624     1.32   0.187    -537.9803     2758.14
------------------------------------------------------------------------------

. vargranger
```

Granger causality Wald tests

```
  +------------------------------------------------------------------+
  |         Equation           Excluded |   chi2     df Prob > chi2 |
  |--------------------------------------+---------------------------|
  |    real_gas_price   futures_com_long |  2.8215     2    0.244    |
  |    real_gas_price                ALL |  2.8215     2    0.244    |
|--------------------------------------+---------------------------|
  |  futures_com_long     real_gas_price |  7.3841     2    0.025    |
  |  futures_com_long                ALL |  7.3841     2    0.025    |
  +------------------------------------------------------------------+

.
. var  real_gas_price   futures_non_long

Vector autoregression

Sample:  3 - 866                         No. of obs      =       864
Log likelihood = -9227.156                  AIC            =  21.38231
FPE           =   6626271                 HQIC           =   21.4034
Det(Sigma_ml)  =   6474645                   SBIC           =  21.43742

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
real_gas_price        5     .437306   0.9749   33503.31   0.0000
futures_non_long      5     5859.39   0.9828   49441.37   0.0000
----------------------------------------------------------------


             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
real_gas_p~e |
real_gas_p~e |
         L1. |   1.204946   .0332725    36.21   0.000     1.139734    1.270159
         L2. |  -.2248425    .033341    -6.74   0.000    -.2901897   -.1594954
futures_no~g |
         L1. |   2.59e-07   2.46e-06     0.11   0.916    -4.55e-06    5.07e-06
         L2. |   1.59e-07   2.46e-06     0.06   0.948    -4.66e-06    4.98e-06
       _cons |   .0904125    .033272     2.72   0.007     .0252005    .1556244
-------------+----------------------------------------------------------------
futures_no~g |
real_gas_p~e |
         L1. |   2153.853   445.8126     4.83   0.000     1280.076     3027.63
         L2. |  -2059.336   446.7312    -4.61   0.000    -2934.913   -1183.759
futures_no~g |
         L1. |    1.19518   .0329041    36.32   0.000      1.13069    1.259671
```

```
 L2. |  -.2084536   .0329252    -6.33   0.000    -.2729857   -.1439214
      _cons |   175.5243   445.8066     0.39   0.694    -698.2405    1049.289
------------------------------------------------------------------------------

. vargranger

   Granger causality Wald tests
  +------------------------------------------------------------------+
  |          Equation           Excluded |   chi2     df Prob > chi2 |
  |--------------------------------------+---------------------------|
  |    real_gas_price   futures_non_long |  1.1271     2    0.569    |
  |    real_gas_price                ALL |  1.1271     2    0.569    |
  |--------------------------------------+---------------------------|
  |  futures_non_long     real_gas_price |  23.828     2    0.000    |
  |  futures_non_long                ALL |  23.828     2    0.000    |
  +------------------------------------------------------------------+
.
.
.
. summarize real_gas_price futures_open_interest ln_real_ng_price  ln_open_interest ///
>           futures_com_short futures_non_short futures_com_long futures_non_long

    Variable |       Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
real_gas_p~e |       866    5.499106    2.749613   2.077087   17.06117
futures_op~t |       866    447396.6    254039.3     110254     971774
ln_real_ng~e |       866    1.590061     .474485   .7309664   2.836805
ln_open_in~t |       866    12.83409     .617185   11.61054   13.78688
futures_co~t |       866    238825.6    97523.88      83355     477839
-------------+--------------------------------------------------------
futures_no~t |       866    72613.33    89716.68        915     396198
futures_co~g |       866    240918.1    106063.1      72102     458476
futures_no~g |       866    45926.31    44583.15       3255     220973
```

APPENDIX B

ECONOMETRIC DATA SOURCES

EIA (U.S. Energy Information Administration) Natural Gas Pricing

Natural gas pricing was obtained from the EIA website going back to 1994 which is the key dependent variable for all econometric models.

U.S. Commodity Futures Trading Commission (CFTC)

Commodity futures contract data were downloaded from the CFTC site with the intent of tracking the positions of noncommercial traders. Noncommercial traders represent mutual funds, hedge funds, or banks that have taken commodity positions. The underlying premise is that when noncommercial traders are taking long positions there is an expectation that price will move upward. Conversely, as short positions are accumulated, traders are expecting prices to fall.

U.S. Department Of Labor Bureau of Labor Statistics

CPI (Consumer Price Index)

In order to analyze prices in Constant rather than nominal dollars, CPI indexes from the Bureau of Labor Statistics were gathered and applied to the relevant price data.

ftp://ftp.bls.gov/pub/special.requests/cpi/cpiai.txt

BIBLIOGRAPHY

Abreu, Dilip, and Markus Brunnermeit, "Bubbles and Crashes," Econometrica Vol 71 No. 1 (January, 2003): pp. 173-204.

Businessweek, "Pumping Cash, Not Oil," http://www.businessweek.com/magazine/content/07_22/b4036057.htm, (accessed November 5, 2010).

Council on Foreign Relations, "China Will Force the World Off Oil," http://blogs.cfr.org/geographics/2010/08/23/chinasoilconsumption/, August 23, 2010, (accessed November 5, 2010).

Dale, Charles and John Zygren, "Noncommercial Trading in the Energy Futures Market," Energy Information Administration, Petroleum Marketing Monthly (May1996): pp. xii-xxiv.

Darday, Joyce M. and Gately Dermot, "World Oil Demand's Shift Toward Faster Growing and Less Price-responsive Products and Regions," www.econ.nyu.edu/user/nyarkoy/OilDemand_DargayGately_Feb2010.pdf, 2010, (accessed November 3, 2010).

Defense Advanced Research Project Agency, "DARPA-RA-10-03 Computer Science – Science, Technology, Engineering, and Mathematics (CS-STEM) Education Research Announcement," https://www.fbo.gov/index?s=opportunity&mode=form&tab=core&id=88b3ebc24fb6377fac6b1107d8d96b84&_cview=0, 2010, (accessed October 29, 2010).

Downs, Erica S., "The Chinese Energy Security Debate," The China Quarterly, No. 177 (March 2004).

Froggatt, Anthony, and Lahn Galda, Lloyds 360° Risk Insight, "Sustainable Energy Security," http://www.lloyds.com/News-and-Insight/360-Risk-Insight/Research-and-Reports/Energy-Security/Energy-Security, 2010, (accessed October 1, 2010).

Institute for Agriculture and Trade Policy, "Commodities Market Speculation: The Risk to Food Security and Agriculture," http://www.iatp.org/tradeobservatory/library.cfm?refID=104414, 2010, (accessed November 6, 2010).

International Association for Natural Gas Vehicles, "Gas Vehicles Report," http://www.iangv.org/tools-resources/statistics.html, 2009, (accessed November 6, 2010).

International Energy Agency, "China Overtakes the United States to Become the World's Largest Energy Consumer," http://www.iea.org/index_info.asp?id=1479, (accessed November 5, 2010).

International Energy Agency, Press Release, http://www.iea.org/press/pressdetail.asp?PRESS_REL_ID=107, (accessed October 24, 2010).

International Energy Agency, "World Energy Outlook 2009," http://www.iea.org/weo/2009.asp, 2009, (November 1, 2010).

Lefton, Rebecca, and Daniel J. Weiss, Center for American Progress, "Oil Dependence Is a Dangerous Habit," http://www.americanprogress.org/issues/2010/01/oil_imports_security.html, (accessed December 14, 2010).

MIT, "The Future of Natural Gas," http://web.mit.edu/mitei/research/studies/report-natural-gas.pdf, 2010, (accessed November 6, 2010).

National Petroleum Council Presentation, "Facing the Hard Truths about Energy," http://www.npchardtruthsreport.org/, 2007, (accessed October 1, 2010).

Natural Gas, "Natural Gas and the Environment," http://www.naturalgas.org/environment/naturalgas.asp, (accessed November 4, 2010).

OECD, Glossary of Statistical Terms, http://stats.oecd.org/glossary/detail.asp?ID=2187, (accessed December 12, 2010).

Sanders, Dwight R., Scott H. Irwin, and Robert P. Merrin, "A Speculative Bubble in Commodity Futures Prices? Cross-Sectional Evidence," (Paper presented at the NCCC-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management St. Louis, Missouri, April 20-21, 2009).

Sanders, Dwight R., Irwin, Scott H., and Robert Merring, "Devil or Angel? The Role of Speculation in the Recent Commodity Price Boom and Bust," Journal of Agricultural and Applied Economics, 41, 2, (August 2009): pp. 377-391.

Sanders, Dwight R., Keith Boris, and Mark Manfred, "Hedgers, Funds, and Small Speculators in the Energy Futures Markets: an Analysis of the CFTC's Commitments of Traders Reports," Energy Economics Volume 26, Issue 3 (May 2004): pp. 425-445.

Smith, Alexander, "Oil is Spiking – Are you positioned?" Seeking Alpha, http://seekingalpha.com/article/228660-oil-is-spiking-are-you-positioned?source=feed, (accessed October 31, 2010).

U.S. Commodity Trading Futures Commission, Historical Reports, http://www.cftc.gov/MarketReports/CommitmentsofTraders/HistoricalCompressed/index.htm, (accessed November 24, 2010).

U.S. Energy Information Administration, Independent Statistics and Analysis, "Coal Explained – How Much Coal Is Left," http://www.eia.doe.gov/energyexplained/index.cfm?page=coal_reserves, (accessed October 31, 2010).

U.S. Department of Energy Office of Electricity Delivery and Energy Reliability Gridworks, "Overview of the Electrical Grid," http://sites.energetics.com/gridworks/grid.html, 2007, (accessed April 12, 2010).

U.S. Energy Information Administration, Independent Statistics and Analysis, "Natural Gas Explained – How Much Gas is Left," http://www.eia.doe.gov/energyexplained/index.cfm?page=natural_gas_reserves, 2009, (accessed November 7, 2010).

U.S. Energy Information Administration, "Oil and Gas Supply Module," http://www.eia.doe.gov/oiaf/aeo/assumption/pdf/oil_gas.pdf, April 2010, (accessed November 3, 2010).

U.S. Energy Information Administration, "2008 Energy Review," http://www.eia.gov/oiaf/archive/aeo08/, 2008, (accessed October 15, 2010).

U.S. Energy Information Administration, "Annual Energy Review 2009," http://www.eia.doe.gov/aer/pdf/aer.pdf, (accessed October 1, 2010).

U.S. Energy Information Administration, "Annual Energy Outlook 2010," http://www.eia.gov/oiaf/archive/aeo10/index.html, 2010, (accessed November 3, 2010).

U.S. Energy Information Administration, "Weekly Fuel Prices," http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMD_EPD2D_PTE_NUS_DPG&f=W, November 2010, (accessed November 6, 2010).

U.S. Energy Information Administration, "Weekly Imports and Exports," http://www.eia.gov/dnav/pet/pet_move_wkly_dc_NUS-Z00_mbblpd_w.htm, (accessed October 31, 2010).

Wikipedia, "Electric Power Transmission," http://en.wikipedia.org/wiki/Electric_power_transmission, (accessed April 12, 2010).

World Bank, "The Recovery," http://siteresources.worldbank.org/INTEAPHALFYEARLYUPDATE/Resources/550192-1270538603148/eap_april2010_ch1.pdf, (accessed October 31, 2010).

World Market Pulse, “Huge Indian Demand to Drive Global Coal Export Boom,” http://worldmarketpulse.com/Investing/Exchange-Traded-Funds/Industry-Sector-ETF/Energy-ETF/Huge-Indian-Demand-to-Drive-Global-Coal-Export-Boom.html, October 1, 2010, (accessed October 29, 2010).