Energy Security and the New Institutional Economics

Paper to be presented at the Mercatus Center, George Mason University, April 19, 2007

By

Margaret Polski, Ph.D.
Center for the Study of Neuroeconomics
George Mason University
Email: mpolski@gmu.edu

April 5, 2007

Abstract

Long-term trends in global growth and new political-economic rivalries create a tight energy market and volatile prices. These conditions make energy security a frequent worry for business and financial analysts and a high priority on policy makers' agendas. Analysts are uneasy because standard analytic approaches often fail to predict behavior in energy markets. And uncertainty makes it difficult for policy makers to compete for adequate supplies at an affordable price. This paper examines how the new institutional economics (NIE) can contribute to developing a better understanding of energy market behavior and draws implications for research, education, and policy making.

"Trends in energy supply and demand are affected by many factors that are difficult to predict, such as energy prices, U.S. economic growth, advances in technologies, changes in weather patterns, and future public policy decisions."

"Oil prices are currently above EIA's estimate of long-run equilibrium prices, a situation that could persist for several more years."

Energy Information Administration, World Energy Outlook 2007

Introduction

Conventionally trained policy analysts assume that producers and consumers make economically rational choices, transactions are made in markets, markets are relatively frictionless, and policies do not change. These assumptions allow analysts to tell a sensible story about complicated questions. And sensible stories help policy makers evaluate equally complicated choices. While these techniques may work well in some situations, they are failing to provide reliable predications about behavior in world energy markets. Instead of producing sense, standard analyses are producing nonsense: weak predictions and poor policy advice. While cynics may argue that we have managed to prosper despite nonsensical advice in many policy domains, energy security is not one where we can afford this kind of slippage.

There are a number of ways in which standard economic assumptions do not pertain to the world energy system. Foremost among them is the assumption that policies will not change. The much ballyhooed new period of global growth and change has arrived. Since 2000, global per capita gross domestic product (GDP) has been rising at the rate of 3.2% per year. What is most interesting about this change is that it is occurring largely in the emerging economies, which have been growing at an average annual rate of 5.6% compared to 1.9% for the developed countries. The combined output of the

emerging economies now accounts for more than half of world GDP and 43% of world trade. Moreover, these countries hold over 70% of global foreign exchange reserves.[1]

In the past, most of the world's GDP has been consumed by 20% of the world's 6 billion people, who reside for the most part in rich countries. However, this pattern is also changing rapidly. A leading indicator is the demand for energy resources, particularly oil, which fuels the underpinnings of commerce and trade. The emerging economies now consume over half of the world's energy and account for four-fifths of the growth in demand for oil.

Global growth trends raise concerns about the ability to produce adequate energy to meet demand. Using standard assumptions, there appears to be little cause for alarm: the evidence suggests that world supplies are adequate to manage a transition from non-renewable to renewable fuels.[2] And prices are rising. For most of the two decades prior to 2000, the world price of crude oil hovered around $20 per barrel. Since 2000, prices have steadily but noisily increased to $61.81 per barrel as of March 30, 2007.[3]

Yet rising prices have not closed the gap between demand and supply: production is constrained by persistent underinvestment in technology, field maintenance, refining capacity, development of renewable substitutes, regulatory obstacles, geological challenges, and disruptions in supply chains created by shortages in supply inputs such as equipment and skilled labor, conflict, piracy, and terrorism.

While higher prices may eventually provide an adequate incentive to make critical investments in energy production, no one is holding their breath. In the past high prices

[1] The Economist (2006).
[2] For an overview of the evidence on peaking, see The Economist (2006c). For an overview of factors influencing global energy supplies, see Yergin (2006).
[3] Source: EIA price statistics.

have also led to rises in inflation and interest rates that have dampened growth.[4] Some estimate that expensive oil may retard growth by 1.5% of GDP.[5] Moreover, prices may not reflect economic fundamentals. Reporting on a dramatic price spike in July 2006, Steven Mufsen of the Washington Post found a preponderance of experts arguing that as much as a third of the increase in oil prices could be attributed to "political factors."[6]

The "political factors" that affect oil prices create considerable consternation for U.S. policy makers. Standard analyses assume that markets form and operate unfettered by government interference. However, the emerging economies are not playing by the rules espoused by the market-oriented developed countries. For starters, few of the top oil producing countries ascribe to liberal political and economic ideals. Political leaders in several of these countries have indicated that they will use oil supplies to realign the geo-political balance of power.[7] The tenor of the international economic dialogue is reflected in remarks by U.S. Senator Richard Luger (R, IN), who chaired the U.S. Senate Foreign Relations Committee until 2007: he compared coercive use of oil supplies to a military attack.[8]

If standard policy assumptions are failing, what tools would be better? At any given time there are a number of critiques of standard assumptions in economic theory but the most enduring comes from institutional economics.[9] Today's incarnation is the

[4] For a more optimistic analysis based upon standard economic theory, see Maugeri (2006). For a more pragmatic analysis, see Yergin (2006).
[5] Economist (2006b).
[6] Mufsen (2006).
[7] Perhaps the best known examples of this are the Ayatollah Ali Khamenei, Iran's top leader, and Hugo Chávez, President of Venezuela. In 2005, their countries controlled 8% of the oil required to meet daily world demand.
[8] As quoted by Bahree and Cummins (2006).
[9] See for example Abramovitz (1993), Kamarck (2001), and Scherer (1999).

new institutional economics (NIE), which aims to explain scientifically the role that rules and organizations play in directing economic activity.

This paper examines how the NIE can be used to analyze energy security and draws implications for research, education, and policy making. Section One describes NIE concepts and tools. The next two sections apply these tools to develop a high level overview of energy security. Section two defines energy security and identifies some of the economic activities associated with it. Section three examines some facts about how the system is organized and governed today. The final section concludes and develops implications.

I. NIE Concepts and Tools

In 1996, Ronald Coase, Douglass North, Oliver Williamson, and a small group of colleagues in the U.S. and Europe joined forces to create the International Society for New Institutional Economics (ISNIE), a multi-disciplinary community of more than 300 scholars who are committed to understanding the role of institutions in economic and commercial life.[10] While there is still much to be learned in the NIE, there are several principles that are widely accepted.

Concepts

First, institutions (the rules of the game) and organizations matter. They matter because they affect the way that traders organize their transactions, which affects the costs of transacting. And the cost of transacting affects productivity, which is the engine of sustainable economic growth. Coase has put it bluntly: "It makes little sense for economists to discuss the process of exchange without specifying the institutional setting

[10] For an overview of the field, see Ménard and Shirley, eds. (2005).

within which the trading takes place since this affects the incentives to produce and the costs of transacting."[11]

Second, NIE applies the tools of economic analysis to understand how institutions and organizations emerge, how they affect choices, interactions and outcomes, and to compare the performance of alternative designs. Unlike the old institutional economics, which emerged from philosophical and historical methodological traditions, NIE has a theoretical and empirical orientation: theory must generate inferences that can be tested with data, and testing is an important part of the NIE project.

However, NIE does not accept all of the assumptions of standard economic analysis. The following propositions reflect commonly accepted points of departure:

- The primary objective of an economic system is not efficient price adjustment but adaptability, which assures that we survive to trade another day and makes price adjustment possible. As Williamson puts it: "Adaptation (through private ordering) is taken to be the central problem of economic organization."[12]
- Adaptation is a dynamic process that cannot be described by general equilibrium models. Douglass North observes: "…the world we live in is non-erogodic – and comprehending the world that is evolving entails new theory, or at least a modification of that which we possess."[13] While we may aim to arrive at equilibrium, if equilibrium is in fact achieved, it is transitory and will soon be disturbed by new choices that reflect the demands of an ever-changing environment.[14]

[11] Coase (1991).
[12] Williamson (2005).
[13] North (2005).
[14] For a more detailed discussions of adaptation in modern economies, see Polski (2001 and 2000).

- Transaction costs are positive. All trade involves transaction costs, which include the costs associated with finding a good or service, arranging for trade, agreeing on the terms of trade, and resolving disagreements about the transaction.[15]
- Polities have many ways of measuring and comparing performance and outcomes: technical and allocative efficiency are only two possible standards. In addition to adaptability and transaction cost economizing, measures may include efficacy, fiscal equivalence, and distributional equity.[16]
- Processes are as important as outcomes.
    - Human choice is boundedly rational.[17] Choice parameters and processes may not conform to standard utility maximizing assumptions and outcomes may not conform to predictions. Humans are neither dispassionate optimizers nor backward-inducting strategists: they are social creatures with complex preference and belief systems that are influenced by the context within which choice occurs. And we sometimes reject choices that appear to improve our position.[18]
    - Choices and outcomes are path dependent. Prior choices and outcomes structure the current choice environment and often limit the set of feasible alternatives. We do not start with a blank slate when we make choices and it is often quite difficult to innovate.

[15] For an overview of the literature on transaction costs and economic governance, see Williamson (2005). For an overview of the costs of exchange see Benham and Benham (2001). For a survey on measuring transaction costs, see Wang (2003).
[16] For a more detailed discussion of alternative measures, see Polski and Ostrom (1999).
[17] This proposition is generally attributed to Herbert Simon (1957).
[18] For an interesting analysis of this problem, see Shirley (2004). Experimental economists and cognitive and social neuroscientists have produced a substantial body of evidence on the role of emotions and social connection in exchange. For an overview, see McCabe (2006).

- Economic and political choices are inextricably linked. Crafting, implementing, and enforcing rules are as much political activities as they are economic activities. Political activity allocates participation and property rights and structures opportunities for competition and cooperation. Economic activity, which allocates scarcity, is affected by how rights, competition and cooperation are structured.

Tools

There are a number of ways in which new institutional economists have adapted conventional analytic tools to improve analysis and policy design. Polski and Ostrom (1999) provide a framework for analyzing transactions, institutions, and political and economic order that includes specifying the following elements: (1) Physical constraints and opportunities including capital and technologies, (2) Community attributes including the characteristics of individuals, groups, and organizations, (3) Rules-in-use (institutions) that define positions, boundaries, authorities, aggregation, scope of action, information, payoffs and provide incentives for action, (4) Action Situation that includes specific choices and the individuals and organizations who are permitted to make them, (5) Interactions (political and economic transactions), and (6) Outcomes. The first three elements structure the choice situation and provide incentives for transacting. The action situation and interactions (transactions) determine outcomes. Figure 1 summarizes the approach.[19]

An important first step in any NIE analysis is to specify the sequence of activities and transactions involved in producing and providing a particular good or service.

[19] For a more detailed discussion of the use of this framework in policy analysis, see Polski and Ostrom (1999).

Approaches to doing this kind of mapping emerged from the scientific management revolution in the early 19th century, which spawned industrial engineering and today's incarnation, "re-engineering." It involves observing activities, drafting process flow diagrams and input-output tables, interviewing those one has observed to verify and more deeply understand why they do what they do the way that they do it, and quantifying impacts.[20]

Another important tool links the consumption characteristics of an economic good or service with alternative economic and political orders. One analyzes the extent to which one person's consumption reduces the supply available to others (subtractability or rivalry), and the extent to which access to consumption can be controlled (excludability), and then arrays the result in a two dimensional matrix with a high/low scale. The analysis (Figure 2) produces four types of goods or services: private, public, club (toll), and common pool.[21]

Private goods, which are the subject of most standard economic models, have high subtractability and high excludability. This means that producers can easily recover their costs and earn a return on investment. Nevertheless, securing a return on investment requires institutions that create participation and property rights, and organizations that are capable of protecting and enforcing them.

[20] A common modern tool is value chain analysis, which has been popularized by Michael Porter (1980).

[21] Private goods include a wide array of personal and commercial consumables including food, beverages, clothing, supplies, and equipment. Examples of public goods include basic education that produces literacy, health care that protects against communicable diseases, law enforcement that protects public safety and property rights, and security against foreign invasion. Infrastructure, banking, and finance are examples of club or toll goods. Common pool resources include renewable and non-renewable natural resources such as forests, fisheries, irrigation systems, minerals, metals, and energy resources. For a comprehensive economic treatment of the nature of goods and externalities, see Cornes and Sandler (1996).

However, when either subtractability or excludability are low, the good or service has a more public character, which makes it more difficult for producers to recover their costs and earn a return on investment – even if rights are secure. Goods and services with a public character are underprovided by classical market relations.[22]

Some private goods and services and all those with a public character have externalities. That is, consumption or production imposes costs or generates benefits that are not separable from the good or services and cannot be attributed to specific consumers or producers.[23] Dealing effectively with externalities requires addressing a number of coordination or "collective action" problems, which requires special institutions and organizations.[24]

When participation and property rights are secure and the good or service has few externalities, markets can emerge and work to the advantage of both private and public interests. On the other hand, markets may not develop or function effectively for goods and services with lower subtractability or excludability, significant externalities, when rights are insecure, or when governments create policies that dampen incentives to trade.

A third tool helps us understand organization and governance at the transaction level. Williamson (1985) observes three types of contracting arrangements in every day economic life: market or classical contracting, trilateral or neoclassical contracting, and relational contracting. He argues that these different types of contracting have emerged because not all transactions are the same: some involve investing in specific assets and

[22] By classical market relations I mean bilateral trade that is unfettered by government intervention or control.
[23] Strictly speaking, an externality is an effect from an economic activity that has consequences that are not reflected in market prices. The producer or consumer does not bear all the costs or reap all the benefits from choice. From a social welfare point of view, too much or too little of the good or service is produced or consumed. Coase (1960) provides an early analysis of the institutional economics of externalities.
[24] Olson (1965).

limited interaction among the parties (complete contracting) whereas others involve investing in assets with less specificity, more interaction between traders, and more opportunity for disputes and disturbances (incomplete contracting). Williamson's contracting schema is reproduced in Figure 3.

Over time traders develop ways to reduce the costs of transacting by creating novel contracting mechanisms that better fit exchange conditions. For example, market contracting and the simple rule of *caveat emptor* may work well for trading in products and services that contain all the information one needs to make a trade such as a buying a cup of coffee, a book, or commodities. But exchanging products and services involving a great deal of technical know-how such as electrical service or medical care may require intermediaries or some kind of certification process that helps consumers determine the competence of providers (trilateral contracting). Joint ventures, custom designed products and services, and large scale projects involving research and development like developing new sources of energy, involve numerous smaller transactions and considerable interaction between buyer and seller over an extended period, which is more consistent with relational contracting than market or trilateral mechanisms.

Now that we have a few tools, we can apply them to energy security and develop some preliminary implications.

II. What is Energy Security?

In this paper I define energy security to mean that one can reasonably expect to meet one's energy needs for the foreseeable future at a cost one can afford. Energy security may or may not involve energy independence, which I understand to mean self-reliance, e.g. one supplies all of one's own energy needs. While energy security may be

analyzed at any level including individual, town, state, country, region, and so on, this analysis focuses on the country level, and specifically the United States.

Energy security is a risky inter-temporal asset transformation process with high barriers to entry. It involves transforming bundles of non-specific public, common pool, private, and club assets into private goods and services that are tradable in markets.[25] These transformations require a diverse assortment of governance mechanisms including relational, trilateral, and market contracting. A high level value chain for energy security includes the following activities, which are summarized in Figure 4.

- *Discovery* includes exploring for new sources of fuel, assessing the quality and accessibility of these sources, and researching and developing alternative technologies.
- *Development* involves obtaining concessions and rights to gain access to production sources, production planning, capitalization including obtaining financial, human, and technical resources, and organizing production.
- *Production* includes site preparation, extraction, refining, and managing operations, safety, security, contract and regulatory compliance, and community relations.
- *Distribution* activities include transportation, storage, risk management, wholesale trading, and retail sales.
- *Reinvestment* involves monitoring operations and relations, maintaining productive capacity, innovation, and environmental management.

[25] For analyses of the challenges associated with inter-temporal asset transformation, see Polski (2006, 2005 a, 2005 b, 2001, and 2000).

Potential sources of energy include hydro power, wind, solar, oil, natural gas, geo-thermal, biomass fuels such as coal, wood, corn, cellulose, and nuclear. All sources of energy except nuclear energy, which is created by a man-made process, are extracted from natural resources. Producing energy from some renewable resources such as hydro, wood, corn, cellulose, and wind, involves converting resources to energy production that potentially have other, competing uses such as producing food and other consumables, housing, commercial development, and recreation. While energy produced from oil, gas, coal, and geo-thermal is less contestable, these resources are not renewable. Energy produced from solar power requires new investments in technology and infrastructure.

U.S. consumers rely primarily on non-renewable fuels: in 2005, liquid fuels and other petroleum products accounted for about 41% of U.S. energy consumption, coal 23%, natural gas 23%, nuclear 8%, biomass 2.3%, and other renewables .01%.[26] Most energy is used in the industrial sector, which accounted for about 32% of U.S. energy consumption in 2005. Transportation accounted for 28%, residential 22%, and commercial 18%. [27]

Imports accounted for 30% of U.S. energy consumption in 2005. Most energy imports are crude oil, liquids, and other petroleum products (85%). U.S. oil imports come from 35 countries in North America (55%), the Middle East (15%), Africa (14%), South America (12%), and Europe and Asia (4%).[28]

Long-term energy security requires that we invest in developing renewable sources of energy that can augment and eventually replace the use of oil and other petroleum products. In the short and medium term, it requires developing and sustaining

[26] EIA (2007).
[27] Ibid.
[28] Ibid.

reliable trade relationships with oil exporting countries. In sum, our energy security depends upon making significant investments in innovation and in strong, mutually beneficial international relationships. And this brings us handily to the topic of organization and governance.

III. How Is Energy Security Organized and Governed?

Every continent and every region of the world has energy deposits. However, as Figure 5 shows, primary energy supplies are concentrated in Asia, Europe, and North America. Primary energy demand (Figure 6) is concentrated in Asia, Europe, North America, and the Pacific. Promising new supplies have been located in Africa, central Europe and North America.[29]

Looking specifically at oil at the country level, the major oil producing countries in rank order (Table 1) include Saudi Arabia, Russia, the U.S., Iran, Mexico, China, Norway, Canada, the United Arab Emirates, Venezuela, Kuwait, Nigeria, Algeria, and Brazil. Eleven of these 14 countries are emerging economies and 3 are developed countries. Seven of these countries are members of the international producer cartel, the Organization of Petroleum Exporting Countries (OPEC).

The top net oil exporting countries in rank order (Table 2) include Saudi Arabia, Russia, Norway, Iran, United Arab Emirates, Nigeria, Kuwait, Venezuela, Algeria, Mexico, Libya, Iraq, Angola, Kazakhstan, and Qatar. Fourteen of these fifteen countries are emerging economies: only Norway is a developed country. Ten of these countries are members of OPEC.

[29] New supplies include unconventional sources located in deep water or in oil sands. Considerable investment is required to make these sources economically viable. For example, Exxon Mobil reports that over the period 2001-2005 it invested $74 billion on six continents to search for new supplies, build new production facilities, expand refining capacity and deploy new technologies. They expect to augment these investments at the rate of $20 billion per year over the next decade.

At the industry level, over 90% of the world's oil and gas industry resources are effectively owned or controlled by the governments of producing countries rather than by private sector firms. As Table 3 shows, 13 of the 15 firms in the world with the largest proven oil and gas reserves are nationally owned companies (NOCs). Only one of the two private sector firms (Exxon Mobil) is based in a developed country: Lukoil is based in Russia.

While most of the world's oil supply is controlled by emerging economies, most of the current demand originates in developed countries. The top net oil importing countries in 2005 in rank order (Table 4) include the United States, Japan, China, Germany, South Korea, France, India, Italy and Spain. The five developed countries in this group account for 72% of world oil imports. However, as the emerging economies continue to grow their demand will outstrip that of the developed countries.

The structure of the global energy system is polycentric: that is, it has no single center of coordination or control but many centers.[30] And there are significant political and economic differences among these centers. Three of the countries in this trading system are inclined to limit government involvement in economic matters: the U.S., the U.K., and Australia. But most of the countries in the system are either "nanny states," where citizens expect government to play a strong role in the economy or authoritarian states, which sharply limit political and economic participation rights.

For example, economic decision making in Canada and the western European social democracies is fairly concentrated and policy makers take a corporatist approach,

[30] For a discussion of polycentricity and the implications for governance, see Ostrom (1972) and Ostrom et al. (1961).

which balances government, business, and labor concerns.[31] The Eastern European countries and India have long standing socialist traditions and are opening to markets in fits and starts with frequent reversals. There are several devoutly communist countries in the system including China, Cuba, and Vietnam, which aspire to forge a "third way." But authoritarianism is perhaps the most common tradition in the global trade system with some countries ruled by strong individuals, families or theocracies, and other putatively democratic countries cycling between military and civil control.

The institutions that are theoretically most closely associated with market and trilateral contracting – secure participation rights, contracting subject to the rule of law, and prudential financial intermediation – reliably function in just four of the top world oil producing countries and in only one of the top net exporting countries. Personal exchange based on relational contracting with limited recourse to the rule-of-law dominates in the remaining countries, which account for 72% of world production and 92% of net exports. Moreover, entire regions in the global energy system are wracked by ethnic and political conflict that frequently disrupts investment and trade and imposes significant, irremediable transaction costs.[32]

IV. Implications

Accelerated global growth creates new demand for energy security. At present, the world is energy insecure because the political and economic order upon which security depends has not evolved to the point where it consistently generates adequate investments in production, refining, and distribution systems, or efficient governance and

[31] For comparative analyses of political-economic choice, see for example Freeman (1989), Katzenstein (1985), and Zysman (1983).

[32] Conflict is a persistent cost of doing business in many of the oil producing countries in the Middle East and Africa. Even when a particular country in one of these regions is stable, border and other regional conflicts increase the hazards and costs of commerce.

economizing. Consequently, there is a mismatch between supply and demand, and price volatility

Potential technical solutions abound. We can change capital, labor, technology, or institutions. We can aim to improve physical security in the global energy supply chain; engage major consuming and producing countries in investment, trade, and diplomacy; encourage political and economic reforms; improve the economic rationality of the oil industry; engineer new risk management products and services; encourage demand-side management; develop substitutes that reduce dependency on non-renewable sources of fuel.

However, standard approaches are failing to generate useful analyses or effective guidance in developing and implementing these types of technical solutions. NIE provides alternative analytic tools, a realistic theory of how energy security can be more efficiently organized and governed, a map of the bottlenecks in the current system, and guidance for strategic change.

Energy security is a complex, quasi-public good, which requires significant, ongoing investment in innovation and a full range of governance mechanisms including market, trilateral, and relational contracting. But conventional energy supplies and production are controlled by governments with limited commitment to the rule of law and a strong preference for relational contracting, whereas scientific and technical resources, exploration, development, distribution, and demand are controlled by individuals and firms with more extensive experience and commitment to the rule of law and a willingness to use a full range of contracting mechanisms.

Mismatches and inefficiencies in the world energy system have a number of implications for research, education and policy-making in the United States. In addition to investing in developing renewable fuels and associated technologies and infrastructure, we need significant new investment in inter-disciplinary social science research. Historical, econometric, and game-theoretic research methods must be augmented by rigorously designed field and laboratory experiments using developments in institutional, experimental and neuro economics, political and military science, law, and neuroscience. Research questions include:

- What are alternative mechanisms that mitigate the social and economic risks of relational contracting based on personal exchange rather than the rule of law?
- How can we create inter-operability between contracting mechanisms based on personal exchange and the rule of law?
- What does it mean to have a resilient energy security system? How can we create and sustain such a system and what are the roles of private, public, and civil sectors?
- How can we create strong, sustainable personal relationships in an international system populated by individuals and groups with quite different values, preferences, beliefs, and capacities?
- What are the dynamics of polycentric systems? How are coalitions built and sustained? How does coordination occur and how does it fall apart? What are the "rules of the game" in healthy polycentric systems?

Second, we need to expand core educational curricula to include topics such as institutional and organizational analysis and design, individual and group differences, understanding our own intentions and the intentions of others, social risk mitigation, negotiation, diplomacy, and dispute resolution.

Finally, we need to re-orient our domestic and international security policies. The pertinent issue is not finding a set of diplomatic, development, or defense strategies that will allow the United States to dominate the global system. Rather, we must accept that we are participants in a polycentric system that may evolve over time but cannot be radically reformed by any means: we cannot assume that we can eliminate those with whom we have differences. Instead we must assume that everyone will survive and focus on the following policy activities:

- Engaging broadly, deeply, respectfully, and strategically to understand "hearts and minds"
- Appreciating differences when we can, tolerating them when we can't, and working to end-run or reduce them
- Identifying and jointly defending common values and interests
- Creating special purpose institutions and organizations to address coordination problems
- Providing assistance that supports joint needs and mitigates exchange risks
- Developing resiliency and exercising "soft" power

Table 1: Top World Oil Producing Countries in 2005*
Source: Energy Information Administration

Country	Production** Million barrels/day
Saudi Arabia (OPEC)	11.1
Russia	9.5
United States	8.2
Iran (OPEC)	4.2
Mexico	3.8
China	3.8
Norway	3.0
Canada	3.1
United Arab Emirates (OPEC)	2.8
Venezuela (OPEC)	2.8
Kuwait (OPEC)	2.7
Nigeria (OPEC)	2.6
Algeria (OPEC)	2.1
Brazil	2.0

*Table includes all countries' total oil production exceeding 2 million barrels per day in 2005
** Production includes crude oil, natural gas liquids, condensate, refinery gain, and other liquids

Average total global daily demand for oil in 2005 was about 84 million barrels per day

Table 2: Top World Oil Net Exporters in 2005*
Source: Energy Information Administration

Country	Net Exports Million barrels/day
Saudi Arabia (OPEC)	9.1
Russia	6.7
Norway	2.7
Iran (OPEC)	2.6
United Arab Emirates (OPEC)	2.4
Nigeria (OPEC)	2.3
Kuwait (OPEC)	2.3
Venezuela (OPEC)	2.2
Algeria (OPEC)	1.8
Mexico	1.7
Libya (OPEC)	1.5
Iraq (OPEC)	1.3
Angola	1.2
Kazakhstan	1.1
Qatar (OPEC)	1.0

*Table includes all countries with net exports exceeding 1 million barrels per day in 2005

Table 3: The World's Largest Oil and Gas Firms
Source: The Economist (2006).

Firm	Country	Rank	Reserves*
Saudi Aramco	Saudi Arabia	1	300
National Iranian Oil Co.	Iran	2	300
Gazprom	Russia	3	>200
INOC	Iraq	4	>100
Qatar Petroleum	Qatar	5	>100
PDVSA	Venezuela	6	100
Kuwait Petroleum Corp.	Kuwait	7	100
ADNOC	United Arab Emirates	8	>50
Nigerian National Petroleum Co.	Nigeria	9	<50
Sonatrach	Algeria	10	<50
Libya NOC	Libya	11	<50
Rosneft	Russia	12	<50
Petronas	Malaysia	13	<50
Exxon Mobil**	USA	14	<50
Lukoil**	Russia	15	<50

* Proven oil and gas reserves in billion barrels of oil equivalent
** Not state controlled (2). All other firms are state controlled (13)

Table 4: Top World Oil Net Importers in 2005*
Source: Energy Information Administration

Country	Net Imports Million barrels/day
United States	12.4
Japan	5.2
China	3.1
Germany	2.4
South Korea	2.2
France	1.9
India	1.7
Italy	1.6
Spain	1.6

*Table includes all countries with net imports exceeding 1 million barrels per day in 2005

Figure 1: Policy Analysis Framework
Source: Polski and Ostrom (1999)

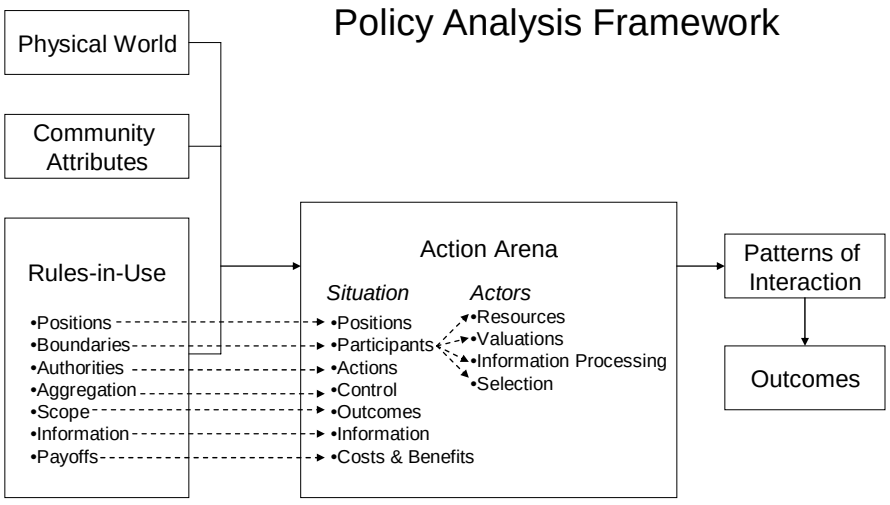


Figure 2: Analyzing the Economic Nature of a Good or Service

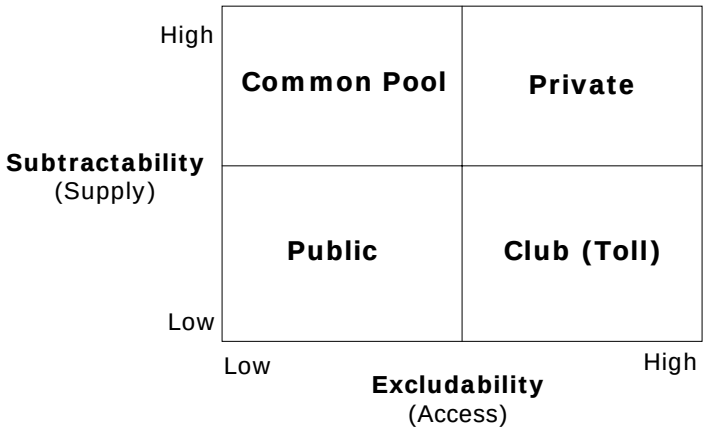


Figure 3: Governing Transactions
Source: Williamson (1985)

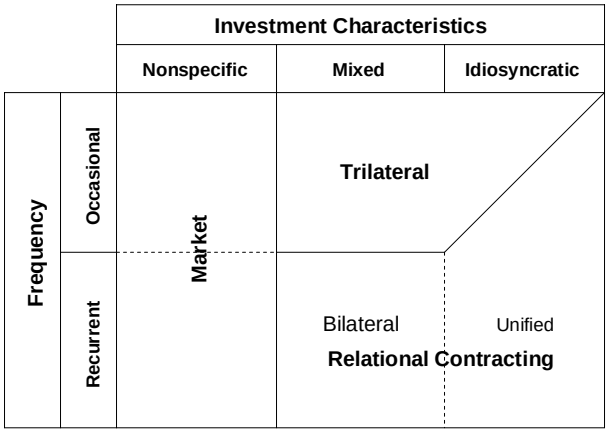


Figure 4: Energy Security Value Chain

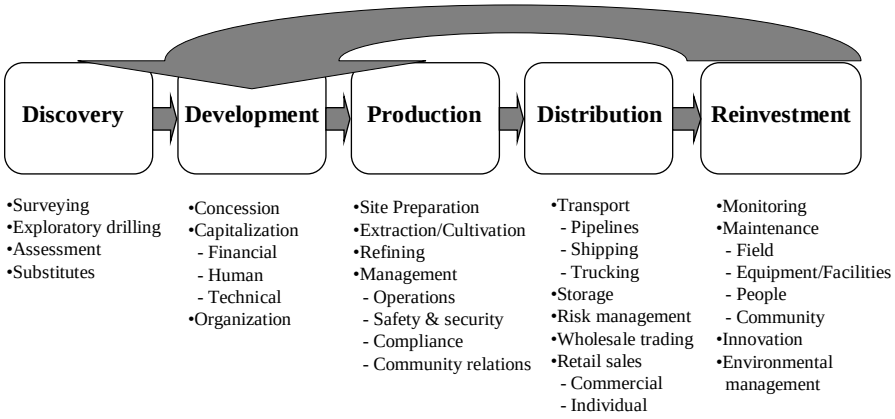


Figure 5: World Energy Resources
Source**:** Organization for Economic Cooperation and Development/International Energy Administration

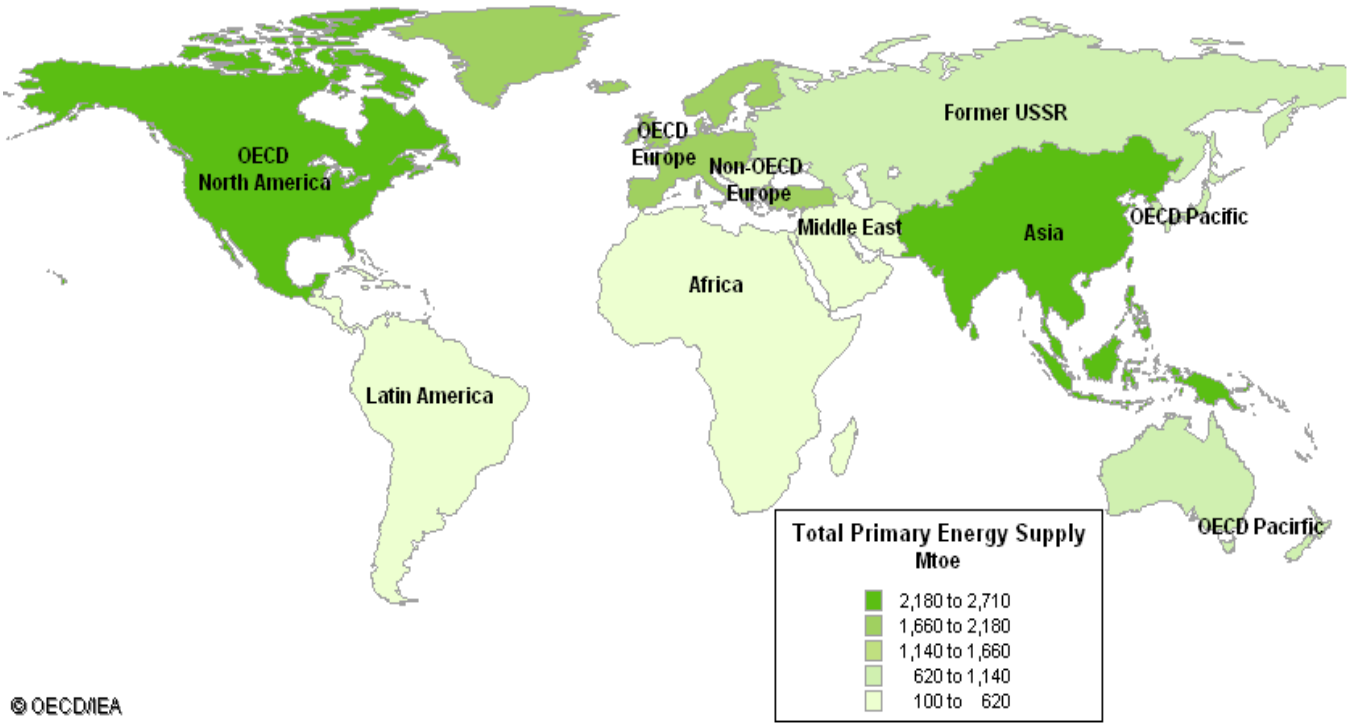
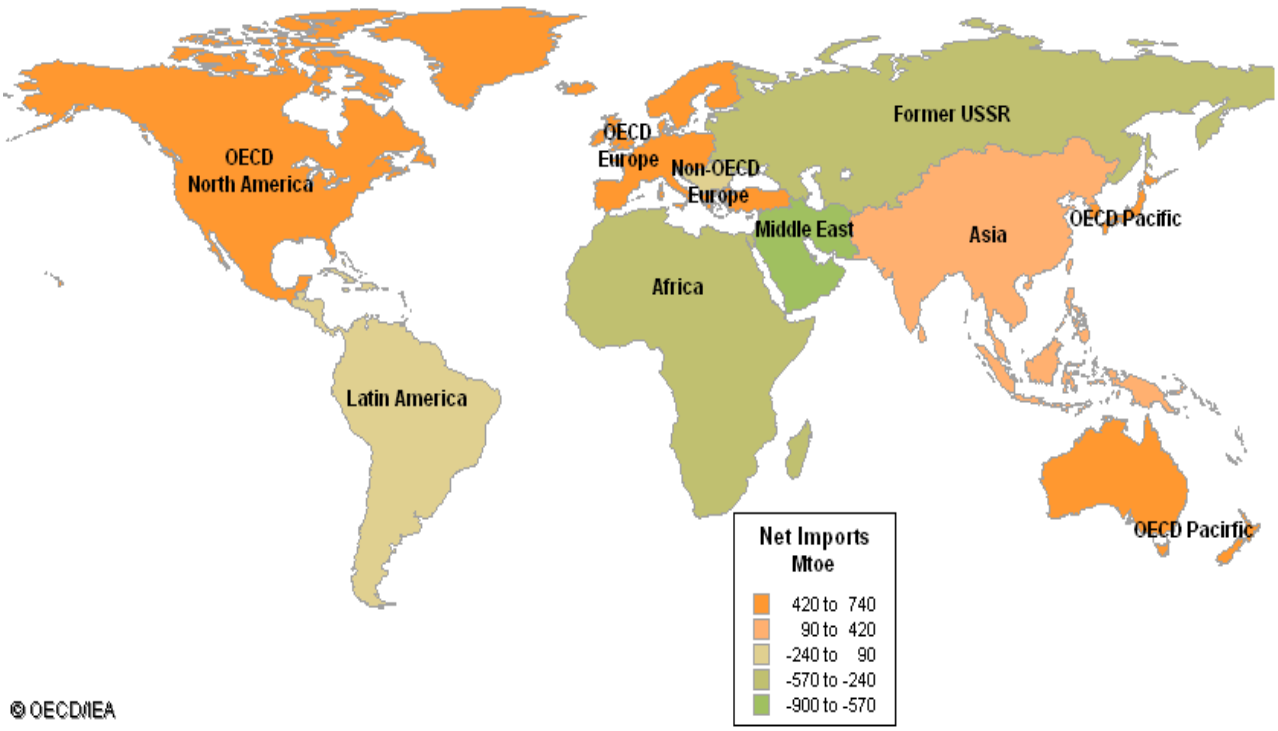


Figure 6: Net Energy Importing Countries
Source**:** Organization for Economic Cooperation and Development/International Energy Administration



References

Abramovitz, Moses. 1993. "The Search for the Sources of Growth: Areas of Ignorance, Old and New. *Journal of Economic History.* Vol. 53:2 (217-243).

Benham, Alexandra and Lee Benham. 2001. "The Costs of Exchange." Coase Institute Working Paper No. 1. July.

Bahree, Bhushan and Chip Cummins. 2006. "In Oil's New Era, Power Shifts to Countries With Reserves." Wall Street Journal. June 14.

Coase, R.H. 1991. "The Institutional Structure of Production." The 1991 Alfred Nobel Memorial Prize Lecture in Economic Sciences, delivered 9 December 1991 in Stockholm, Sweden. The Nobel Foundation.

_____1960. "The Problem of Social Cost." Journal of Law and Economics, Vol. I.

Cornes, Richard and Todd Sandler. 1996. *The Theory of Externalities, Public Goods, and Club Goods.* Cambridge University Press. Cambridge: UK.

The Economist. 2006. "Survey of the World Economy." September 16.

_____. 2006 a. "Oil's Dark Secret." The Economist. August 12.

_____. 2006 b. "Big Questions, Big Numbers." The Economist. July 15.

_____. 2006 c. "Steady As She Goes." The Economist. April 22.

Energy Information Administration. 2007. "Annual Energy Outlook 2007 with Projections to 2030." Washington, D.C.: EIA. DOE/EIA-0383(2006) February.

Freeman, John R. 1989. *Democracy and Markets: The Politics of Mixed Economies.* Ithaca, NY: Cornell University Press

Kamarck, Andrew M. 2001. *Economics for the Twenty-first Century: The Economics of the Economist-Fox.* Burlington, VT:Ashgate.

Katzenstein, Peter J. 1985. *Small States in World Markets: Industrial Policy in Europe.* Ithaca, NY: Cornell University Press.

Maugeri, Leonardo. "Two Cheers for Expensive Oil." Foreign Affairs. March/April, 149-161.

McCabe, Kevin. 2006. "The Neuroeconomics of Personal and Interpersonal Decision Making." In De Crimer, David, Marcel Zulenberg, and J. Keith Murnigham. Eds.

2006. *Social Psychology and Economics.* Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Ménard, Claude and Mary M. Shirley, eds. 2005. *The Handbook of New Institutional Economics.* Dordrecht, The Netherlands: Springer.

Mufson, Steven. 2006. "A Price Inflamed By Fear." The Washington Post. July 14.

North, Douglass C. 2005. *Understanding the Process of Economic Change.* Princeton, NJ: Princeton University Press.

Olson, Mancur. 1965. *The Logic of Collective Action.* Cambridge, MA: Harvard University Press.

Ostrom, Vincent. 1972. Polycentricity. Presented at the Annual Meeting of the American Political Science Assocation, Washington, D.C., September 5-9. Reprinted in: McGinnis, Michael, ed. 1999. Polycentricity and Local Public Economies: Readings from the Workshop in Political Theory and Policy Analysis. Ann Arbor: University of Michigan Press.

Ostrom, Vincent, Charles M. Tiebout, and Robert Warren. 1961. The Organization of Government In Metropolitan Areas: A Theoretical Inquiry. The American Political Science Review. Vol. 55, Issue 4, pp. 831-842. December.

Polski, Margaret M. 2006. "The Economic Organization of Biomedical Research in the United States." International Social Science Journal. Fall.

_____. 2005 a. "The Institutional Economics of Biodiversity, Biological Materials, and Bioprospecting." Journal of Ecological Economics. April.

_____. 2005 b. "The Institutional Economics of Exchanging Biological Materials and Biomedical Research." Paper Presented at the 9th Annual Conference of the International Society for New Institutional Economics, Universitat Pompeu Fabra, Barcelona, Spain. September 22-24, 2005.

_____. 2001. "Growth and Change in the New Economy: Opportunities and Challenges." In Audretsch, D. and Welfens, P.J.J., Eds. *The New Economy and Economic Growth in Europe and the U.S.* Heidelberg: Springer-Verlag.

_____. 2000. "Sustaining Innovation and Growth in Research-Intensive Industries: Early Stage Finance Issues & Approaches." Discussion paper prepared for the Board on Science, Engineering, Technology, and Economic Policy, National Research Council, National Academy of Sciences, Washington, D.C. August.

Polski, Margaret M. and Elinor Ostrom. 1999. “An Institutional Framework for Policy Analysis and Design.” Workshop in Political Theory and Policy Analysis Working Paper W98-27. Indiana University, Bloomington, IN.

Porter, Michael E. 1980. *Competitive Strategy: Techniques for Analyzing Industries and Competitors.* New York, NY: The Free Press.

Scherer, F.M. 1999. *New Perspectives on Economic Growth and Technological Innovation.* Washington, D.C.: British-North American Committee, Brookings Institution Press.

Shirley, Mary. 2004. “Why is Sector Reform So Unpopular in Latin America?” Ronald Coase Institute Working Paper No. 4. January.

Simon, Herbert. 1957. *Models of Man.* New York, NY: John Wiley and Sons.

Yergin, Daniel. 2006. “Ensuring Energy Security.” Foreign Affairs. April/May, 69-82.

Wang, Ning. 2003. “Measuring Transaction Costs: An Incomplete Survey.” Ronald Coase Institute Working Paper Number 2. February.

Williamson, Oliver E. 2005. “The Economics of Governance.” Working Paper. University of California, Berkeley. January.

_____. 1985. The Economic Institutions of Capitalism. The Free Press, New York.

Zysman, John. 1983. *Governments, Markets, and Growth: Financial Systems and the Politics of Industrial Change*. Ithaca, NY: Cornell University Press.