Chapter 28
The Repercussions of Being Addicted to Oil: Geospatial Modeling of Supply Shocks

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28.1 Introduction

Energy security is a growing concern for many nations around the world. According to the *CIA Factbook*, over 50% of the world's oil reserves are in the hands of five nations: Saudi Arabia, Canada, Iran, Iraq and Kuwait. Natural gas is also highly concentrated, with Russia in control of the largest reserve. Political instability, attacks against energy infrastructure, attacks against transportation vessels, natural disasters and military aggressiveness in energy supplying countries can have profound global and local economic repercussions. Russia's invasion of Georgia in 2008, as an example, wreaked havoc on oil prices and posed an economic threat to much of Europe and other parts of the world that depend on oil and natural gas from that region. Georgia is a key transshipment node in the movement of Caspian crude oil and natural gas to markets in Europe and beyond. The 1,109 mi (1,785 km) British Petroleum Baku-Tbilisi-Ceyhan (BTC) pipeline, one of the largest in the world, runs straight through Georgia and carries upwards of 1 million barrels of oil a day. The Russian attack on Georgia is a clear illustration of how geopolitical tensions can upset the energy market through a shock to oil prices and ultimately threaten regional economies.

While there is a substantial and growing body of literature focused on the geopolitical nature of energy and the effect of supply shocks on oil prices, very little of this research addresses the geographic implications of supply disruptions resulting from terrorisms, military aggression or violence The massive infrastructure created to extract oil, refine oil, move oil, and convert it into energy is one of the largest in human history. Further this infrastructure has profoundly impacted the earth not only environmentally, but also as a source of conflict and often adverse economic impacts across a global society.

Specifically, there is a lack of research that attempts to measure the extent to which nations are at risk of being adversely affected by supply disruptions and how

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the effects vary geographically. While there are a handful of studies that do develop indices for measuring the oil dependence and vulnerability of a nation to supply disruptions, the application of these measures has been confined to limited geographies such as nations in South Asia (Center for Energy Economies, The University of Texas at Austin, 2008), APEC member countries (Asia Pacific Energy Research Center, 2007) and the OECD (Alhajji & Williams, 2003). This paper builds on this literature and develops a set of comprehensive measures of energy security, with a particular focus on the measurement of risk to nations of terrorism and other forms of violence in energy-producing countries, along critical transshipment points or against infrastructure. Since the discovery of oil a valuable national commodity the infrastructure it is dependent on has been a target of both nation state and rogue actors as well as impacted by natural disasters. The results of these actions have often had very adverse impacts on society, economically, and the earth, environmentally. The indices developed in this paper are applied to 63 nations in the world and will specifically focus on societal economic impacts.

Following this Introduction, Section 28.2 provides an overview of the literature that looks at the effects of geopolitical events or terrorism on the energy market and the geographic dimensions of the problem. In Section 28.3, we describe the indices that are used in this paper to measure the geospatial risk of a supply shock and the results of the analysis. The paper ends with some conclusions and policy recommendations.

28.2 The Geopolitics of Oil: An Overview of the Literature

Economic research into oil price shocks is primarily concerned with the question: how much do these shocks affect the performance of the macroeconomy? On the one hand James Hamilton has made a well established argument for the tendency of oil price shocks to precede recessions and slowdowns in the US economy (Hamilton, 1983). On the other hand, individuals have argued that it is not clear that oil price shocks are such a significant precursor to recessions (Barsky & Kilian, 2002; Blanchard & Gali, 2007). One of the problems with asking the question "do oil price shocks cause recessions?" is figuring out the direction of causation, that is, are oil prices exogenous to macroeconomic conditions to begin with?

Of the many ways to talk about the absolute and relative levels of oil prices, one is to describe the conditions of the supply and demand for oil a-spatially. Economists have found that the elasticity of demand for oil with respect to its price is historically low (from 0.1—Short Run—to 0.3—Long Run), and has been decreasing according to recent data (Hamilton 2008). Increasingly, consumers of oil are becoming less responsive to changes in price. Changes in the supply of oil, therefore, have a greater effect on the price of oil than on the quantity produced (Lippi & Nobili, 2008). The importance of this point can be understood with respect to the volatility of oil supply. The ability and cost of supplying oil is subject to natural disasters, wars and political forces, including terrorism. With a decreasing elasticity of demand for oil, one should expect to see the volatility of oil supply situations play out more dramatically in the price of crude oil.

Of course, the supply and kind of oil varies across countries and space, meaning that the cost of extracting and refining oil varies across nations. However, in general, the final price of oil is a global one. So whether it costs 3 times as much to extract oil in the US as it does in Saudi Arabia, oil is generally sold for the same price around the globe. Political particularities, such as the longtime US subsidy of gasoline, will of course vary from country to country. But in general, if it costs \$10 per barrel in Saudi Arabia and \$20 in the US, and the maximum price at which oil is demanded is \$15, then oil production will not take place in the US. On the other hand, should a terrorist incident in Saudi Arabia raise the price of production to \$12 then a profit can still be had and one can assume that production will continue in Saudi Arabia. The implications of this point are that, should terrorism increase the cost of supplying to producers in one particular area, the effects on the global price of oil are dependent on the costs which that area faces in production relative to global demand and other suppliers' costs.

Much of the world's supply of crude oil comes from nations rather than singular private suppliers. Take, for example, ExxonMobil, which accounted for only about 3% of global oil production in 2007. The OPEC-10 countries (Algeria, Indonesia, Iran, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela) were responsible for 37.5% of the world's output in 2007. Of these countries, Saudi Arabia's output accounted for about one-third. Given their quasi-monopolist position in the market, it is instructive to understand them as setting their price with respect to demand elasticity. Hamilton estimates that, given estimates for demand elasticity, we might expect Saudi Arabia to markup the price of its crude oil 1.86 times the cost of extracting it (Hamilton, 2008). The production decisions of the other OPEC countries seem to be largely political, with some historically producing above and some below their agreed quotas. As one author puts it,

> Producers within importing countries have an incentive to undermine international negotiations. Whilst there is an incentive for both consumers and the cartel to negotiate international supply agreements, there remains the incentive for producers to break their agreements subsequently, causing mistrust and potential conflict.
>
> (Newbery, 1981)

As an exercise in understanding the mechanisms by which oil prices are determined, Hamilton asks the question: what caused the high oil prices in the summer of 2008? He concludes that high oil prices were cause by

> Commodity price speculation, strong world demand, time delays or geological limitations on increasing production, OPEC monopoly pricing, and increasingly important contribution of the scarcity rent.
>
> (Hamilton, 2008)

It is not any one of these things which cause high oil prices, but their interaction. Take, for example, the case of speculators bidding up the price of oil futures. The speculators' ability to turn a profit depends on the price elasticity of demand for oil, as well as on the inability of producers to radically increase production. What's more, countries like Saudi Arabia may have found that as speculation happens, they can increase their revenue by cutting back on supply. The colossal investment made by oil producing nations in infrastructure—extraction, refining and transportation—provides the economic mechanisms to control supply of oil to the market and allowing strong influence on global oil pricing.

It is well known that oil-producing countries often act as political entities, limiting and allowing the production of oil for both political and monopolistic reasons. Research into the strategic behavior of countries and oil groups such as OPEC with respect to the price of oil is well-developed, although the behavior of these groups is obviously determined by demand and supply conditions. That is, any one of the political entities which produces oil not only determines the price of oil, but may react to it. Even OPEC decisions, which are widely understood as independent of the price of oil, are quite possibly determined by it (Barsky & Kilian, 2002: 125).

In general, major shocks in oil prices are not always related to exogenous political events (Barsky & Kilian, 2002: 125). For example, the price increase between March 1999 and November 2000 was not accompanied by military conflicts. Furthermore, oil prices fell after November 2000 as international conflicts increased. Some argue that this time period saw exogenous political events in the form of OPEC market engineering—where OPEC uses the collective infrastructure of their member to control supply to market providing de facto control of prices. However, Barsky and Kilian (2002) argue that OPEC decisions are not in fact exogenous and do respond to market conditions. As political events, other have hypothesized that terrorist attacks are not responsive to market conditions. It is conceivable to imagine that they are exogenous to oil prices and market conditions and that their effect on prices can be considered isolated from other factors.

In an unpublished paper, one pair of authors attempts to use terrorist attacks as an instrumental variable because of the conceivability of their being exogenous (Chen, Graham, & Oswald, 2008). While this paper does not concern itself with a largely econometric debate, the conclusion is that

> . . .terrorist incidents, when combined with a lagged level of oil prices, can explain approximately one quarter of the variation in the price of petroleum.
>
> (Chen et al., 2008: 15)

Given the importance of terrorist events in determining the increasingly volatile price of oil, how might we approach the problem of identifying exactly how a terrorist attack relates to the final price of oil? Chen and Graham look at the effect that a terrorist attack has on the costs to producers. Yet another approach is to ask if the market speculates about the effect of terrorist events on the price of oil. In the latter question, speculation is difficult to disentangle from the market as a whole.

One specific example of how violence can affect the price of oil is the case of armed conflict in Columbia. Dunning and Wirpsa (2004) demonstrate that attacks on pipelines in 2001, along with other factors, led to a reduction in production of 25% (from 800,000 to 600,000) in 1999. Guerrillas in Colombia have dynamited pipelines more than 1,000 times since 1991. They estimate that the Cano Limon-Covenas pipeline lost almost $1 billion worth of crude oil between 1990 and 1995.

Pipelines in Columbia are also vulnerable to siphoning of gasoline. To protect their facilities, companies must spend money for protection or buy off threatening organizations. While it may be difficult, as we have noted, to specify the mechanisms by which such increases in cost affect the final price of crude oil, it is very likely that a quick cut in supply will increase the cost of production locally. In the long run, we might expect production to shift locations strategically; but in the short run fixed costs may mean an increase in prices.

Oil must be locally extracted and then physically transported before it can reach the theoretically global market in which it is finally sold. As Dunning and Wirpsa put it,

> . . .oil is vehemently and simultaneously local, regional, national, and global. It is characteristically 'fixed'; therefore, extraction must occur at the specific focal point of its location. This means the exploitation of oil has particular consequences for the security of the communities and territories in which it is embedded. Control of oil, however, requires the infrastructure, security and technology to convert it into an asset transportable over and through broad and complex regional, national, and transnational-national geographic space, usually across national borders.
>
> (Dunning & Wirpsa, 2004: 82)

This situation creates a significant driver for investment in megaengineering projects because it results in both economic and military power, and makes control of the infrastructure a national priority across the globe. Because of its physical characteristics, the supply of crude oil is perhaps most vulnerable to an interruption by terrorist attack during transportation. For example, in the Persian Gulf 88% of the oil is exported through the Straits of Hormuz by tanker (Billon & Khatib, 2004) (Fig. 28.1).

Another possible mechanism by which terrorist attacks may affect crude oil price is via information about oil price events and terrorism that is communicated, received, understood, and analyzed. For example, one might examine the effect of

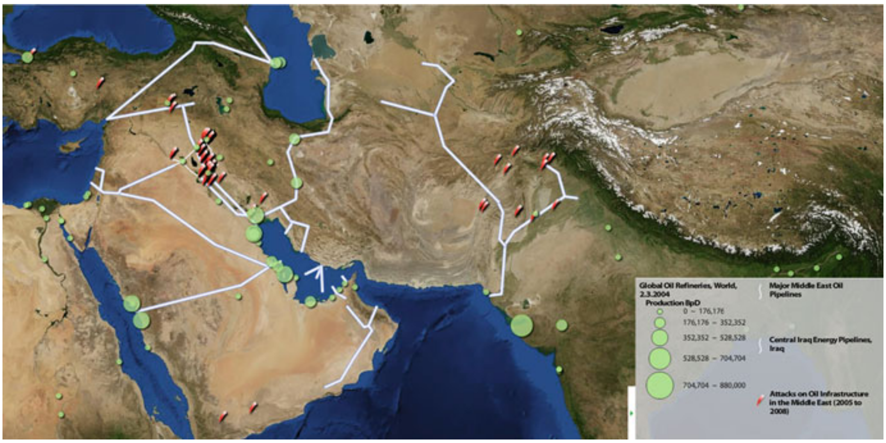

Fig. 28.1 Major oil pipelines and terrorist attacks

targeted terrorist attacks on price via speculation and look at where the producer is based.

When considering the effect of terrorist events on the price of oil one might hypothesize that speculation could be one mechanism by which prices are affected. The literature on the effect of news stories on stock markets shows that stock markets tend to overreact to news events. In general, the effects of an event should be taken into account in terms of how people revise their expectations afterward (Niederhoffer, 1971). In the case of crude oil prices, this would mean that if a significant supply disruption was expected, manifestations of this in the market might include people storing oil or bidding up the future price of it. In general, stock markets overreact to dramatic and unexpected events. Also, a "losers" stock portfolio will typically experience very large January returns as much as three to five years after the formation of the portfolio. (De Bondt & Thaler, 1985) That is, a portfolio of stocks which has experienced negative news will experience a short run fall in their prices, but the effects do not seem to last into the long run. We may expect that the price of crude oil will have a similar relationship to the "bad news" of terrorist events. The mechanisms through which investors speculate about the price of oil may also be important. For example, shorting oil may be more expensive than buying it (Chan, 2003). If so, could this explain stronger reactions to negative news in oil prices relative to reactions to positive news?

While the effects of terrorism and violence, and even speculation about such activities, can under certain circumstances have global ramifications, the impacts on individual nations vary tremendously. In large part, the potential for a country to be adversely impacted by a supply disruption or spike in the price of oil depends on its degree of energy security. Parry and Darmstadt (2004) define energy security as a set of conditions that protect the health of an economy against circumstances that threaten to substantially increase the costs of supplying and consuming energy.

Generally, there are two factors that can affect the energy security of a nation. One is related to oil import vulnerability. Nations are more vulnerable if they rely heavily on oil imports from unstable regions, countries that control the market (e.g., OPEC) in terms of supply or access to resource or remote locations in which case there is a greater chance for sabotage involving the transshipment of oil. Shannon entropy has been used in the literature to measure oil import vulnerability and a variation of this that adjusts for the geostability of the exporting nations has also been developed (Hirschhausen & Neumann, 2003; Jansen, van Arkel, & Boots, 2004).

However, just because a nation is vulnerable to a disruption does not mean that it has the potential to be negatively affected. Dependency on oil is another critical factor. Some of the ways in which a country's dependence on oil can be measured include its reliance on oil imports to satisfy demand for the resource, oil consumption in relation to Gross Domestic Product (GDP), import share of product supplied, oil used per capita and degree of energy diversity, that is,, use of and access to alternative energies. For nations that do not have indigenous oil supply, the need to decrease oil dependency also drive megaengineering projects such as nuclear power, wind energy, solar energy, geothermal and hydroelectric. Shannon entropy is commonly used to measure energy diversity (see e.g., Center for Energy

Economies; The University of Texas at Austin, 2008; Asia Pacific Energy Research Center, 2007).

In this paper, we draw upon some of the indices that have been introduced in the literature and measure the energy security of 63 nations in the world. The next section describes the composite indices we use to measure the two elements of energy security: oil import vulnerability and dependency on oil.

28.3 The Geospatial Risk of Oil Supply

The import vulnerability of a nation is assumed to be a function of three factors: diversity of oil imports adjusted downward by the political instability of the exporting nations, the percent of imports that come from the top 10 producers, and share of imports that come from points outside of the region in which the nation is situated. Vulnerability is defined as a weighted function of the three components, as follows:

$$V_i = w_1\,{}^{*}ID_i + w_2\,{}^{*}TOP10_i + w_3\,{}^{*}NLOC_i \tag{28.1}$$

where, $V_i$is the import vulnerability of nation i, $TOP10_i$, is the proportion of imports to nation i that come from the top 10 exporters in the world, $NLOC_i$ is the share of imports to nation i that come from outside of the region in which it is located and the w's are weights that sum to unity. Equal weights were applied to Equation (28.1). According to the *CIA World Fact Book*, the top 10 oil exporters in bbl per day in 2008 were Saudi Arabia, Russia, Norway, the UAE, Iran, Canada, Mexico, Venezuela, Nigeria and Kuwait. The index, NLOC, is calculated based on the following definitions for regions: North America, South and Central America, Europe, Former Soviet Union, Africa, Asia, the Middle East and Australasia.

Shannon-Weiner-Neumann entropy is used to capture the vulnerability of a nation to supply disruptions due to geopolitical factors. For each nation, we divide entropy by the natural logarithm of the total number of countries it imports from to arrive at an index that ranges between 0 and 1, where higher values indicate greater vulnerability. Specifically, the index is formulated as:

$$IV_i = ID_i/D_{\max} \tag{28.2}$$

where, $D_{\max}$ is the maximum entropy possible given the total number of exporting nations and ID_i is the entropy diversity adjusted for the geo-stability of the exporting nations. It is represented as follows:

$$ID_i = -\sum_{j=1} p_j(\ln P_j)\, c_j \tag{28.3}$$

where P_j is the share of imports to nation i that come from country j and c_j is a weight that reflects the stability of exporting country j. In this paper, we use the World Bank's Index of Political Stability and Absence of Violence/Terrorism, one of six indices they use to measure different aspects of governance (Kaufmann, Kraay, & Mastruzzi, 2008). The index ranges from 0 to 1, with higher values indicating greater stability.

One of the challenges in measuring import vulnerability, based on Equation (28.2), is that up to date and detailed data on oil imports by country of origin are publicly available only for a select set of nations. It was, therefore, necessary to derive estimates of oil trade flows for the countries that we wanted to analyze. To do this, we first partition the region-to-region oil trade flows in thousands of barrels per day reported in the *British Petroleum Statistical Review of World Energy* (2008) country-to-country flows based on the shares of imports and exports from each of the nations for which had data. More specifically, for each importing country, the share of oil imports from each region were estimated using the share of imports to the region in which it is located and then those flows were further broken down by using the share of exports from each nation within the different export regions. For example, the imports for Ecuador by country of origin in the Middle East region were estimated by first taking the share of exports from the Middle East going into the South and Central America region. Then, secondly, the total exports going to Ecuador from the Middle East were further broken down by using information of the share of total exports for each country in the Middle East. Within-region flows were estimated through a similar method using the British Petroleum data.

Oil dependency is assumed to be a function of three factors: net oil imports to oil consumption (bbl a day), oil consumption in relation to Gross Domestic Product, and two indicators of energy diversity. Similar to oil import diversity, dependency on oil is formulated as a weighted function of each of the factors as follows:

$$DEP_i = w_4 \,{}^*IC_i + w_5 \,{}^*OGDP_i + w_6 \,{}^*\, EDIV_i \tag{28.4}$$

where, the w's are weights that add to unity, IC_i is country i's net imports of oil to consumption, $OGDP_i$ represents a nation's consumption of oil in relation to its Gross Domestic Product and $EDIV_i$ is a Composite Index of Energy Diversity for nation i. The OGDP index was normalized using the high and low values in the series, such that it was confined to a range of 0 to 1. The index of energy diversity is as follows:

$$EDIV_i = w_7 \,{}^*OD_i + w_8 \,{}^*ED_i \tag{28.5}$$

where, the w's are weights that sum to unity, OD_i is oil demand in relation to demand for all energy types and ED_i is index of energy diversity based on Shannon's entropy, given by:

$$ED_i = 1 - (ESD_i)/(ESD_{\max}) \tag{28.6}$$

$$ESD_i = \sum_{k=1}^{k} E_k \ln E_k \qquad (28.7)$$

where, ESD_i is a Shannon entropy index of energy diversity, $ESD_{\max}$is the maximum value for the entropy based on total number of energy types k and $E_k$is the share of energy demand in country i for energy type k. We divide through by the maximum value possible for the entropy given k and then subtract the value from one to arrive at an index that ranges between 0 an1 where larger values indicate less diversity. The energy types we use to calculate the index include oil, natural gas, nuclear energy and hydroelectricity and the shares for each are based on the consumption figures reported in the *British Petroleum Statistical Review of World Energy* (2008). These data are is in terms of millions of oil equivalent.

Other data used to calculate the oil dependency include oil imports and consumption in bbl's per day from the 2008 *CIA Factbook* (Central Intelligence Agency, 2009) and estimates from the IMF *World Economic Outlook* (2008) Gross Domestic Product in current United States dollars. Uniform weights were applied to Equation (28.4) and the two components of the energy diversity index (28.5) were also equally weighted.

28.4 Results of the Analysis

The results of the analysis reveal that there is significant geographic variation in oil import vulnerability and oil import dependence, and for some of the factors that go into these two aspects of energy security, there are regional similarities.

Figure 28.2 shows the vulnerability of nations to supply disruptions, based on the oil import vulnerability Equation (28.1). Countries that rank high in terms of vulnerability include Japan, China, Australia and New Zealand. The least vulnerable are a set of nations scattered in different parts of the world: Norway, Mexico, South Korea, Bangladesh, Philippines and Iceland. Qatar, Venezuela and Saudi Arabia were not included in the vulnerability analysis since they are countries that do not import oil.

One region that depends heavily on imports from the top suppliers in the world is the Former Soviet Union. Other countries that fall into this category include Japan, China, and the United States. Those that are reliant more on marginal producers include Australia, New Zealand, Mexico, Norway and countries in Asia, excluding China, Singapore and Japan. It should be noted that some of the nations that rely heavily on oil from the export giants have, on the contrary, diverse sources of supply. This is based on Equation (28.3), absent the adjustment for the political instability of the source destinations. Two countries that fall into this category include United States and China. What is interesting is that when the stability of the suppliers is reflected in the measurement of diversity, the results change quite significantly. Figure 28.3 shows the percent reduction in import diversity when the potential for geopolitical tensions to disrupt supply are reflected in the index. China and the

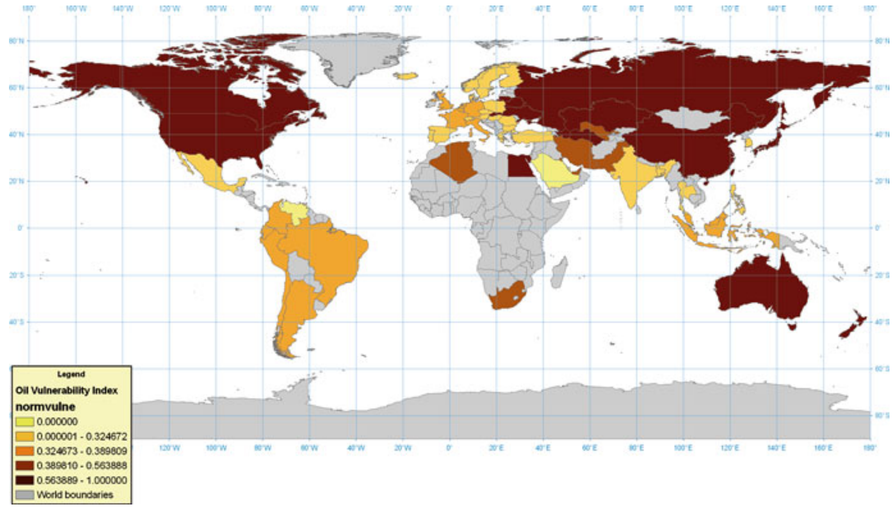

Fig. 28.2 Oil import vulnerability

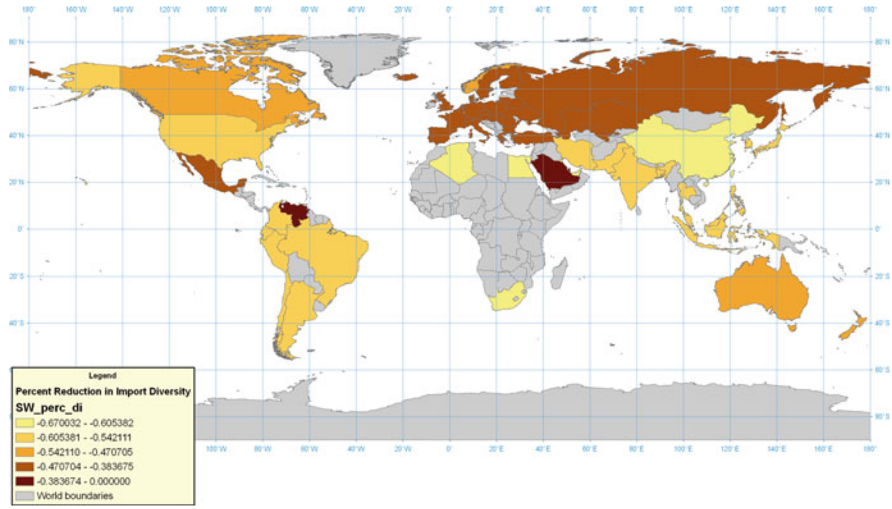

Fig. 28.3 Percent reduction in import diversity

United States have some of the largest reductions in diversity. Another interesting finding is that there appears to be some regional effects. Specifically, the largest percent reductions are in large parts of Asia, South America and North America. These regions are also the ones that are most vulnerable to supply disruptions resulting from terrorism, violence or military aggression.

Vulnerabilities associated with the transportation of oil, reflected in the index NLOC, are highest in parts of Asia (Japan, China), much of the Former Soviet Union and Canada. South America and Europe are the least vulnerable in terms of this index.

The analysis reveals that the nations that are most dependent on oil, based on the factors that comprise Equation (28.4), are largely concentrated in Asia (Singapore, South Korea, Taiwan, Thailand and Philippines)—although, Belarus, Greece and Bangladesh also come out high in the rankings. Least dependent are nations in northern Europe (Norway, Denmark, United Kingdom), parts of South America (Columbia, Argentina), Canada, Mexico and Russia. Not surprising these are oil-exporting nations. These results are displayed in Fig. 28.4.

The reasons for oil dependency vary considerably by nation and region. Most parts of Europe rely heavily on imports to satisfy consumption needs, that is, net imports to consumption is high for those countries. Neither are the nations of Europe economically dependent, based on oil consumption in relation to Gross Domestic Product. Countries that are economically dependent include some in the Middle East (Saudi Arabia, Egypt and Iran), others in the Former Soviet Union (Uzbekistan, Turkmenistan) and Singapore.

The geographic patterns of energy diversity look quite different than those for economic dependence. Nations that consume a high share of oil in relation to the demand for all types of energy are scattered around the globe. Venezuela, Turkey, Italy, Indonesia, the United States and Peru are all highly oil-dependent according to these criteria. Venezuela, at the top of the list, consumes an amount of oil that is nearly 88% of the demand for all forms of energy. Nations that rank low in terms of this index include Norway, parts of Eastern Europe (Romania, Bulgaria) and areas in the Former Soviet Union (Uzbekistan, Ukraine, Russia). Energy diversity, based on the mix and balance of demand from multiple types of energy—oil, natural gas, coal, wind and hydroelectricity, is the worst in Singapore and some of the oil

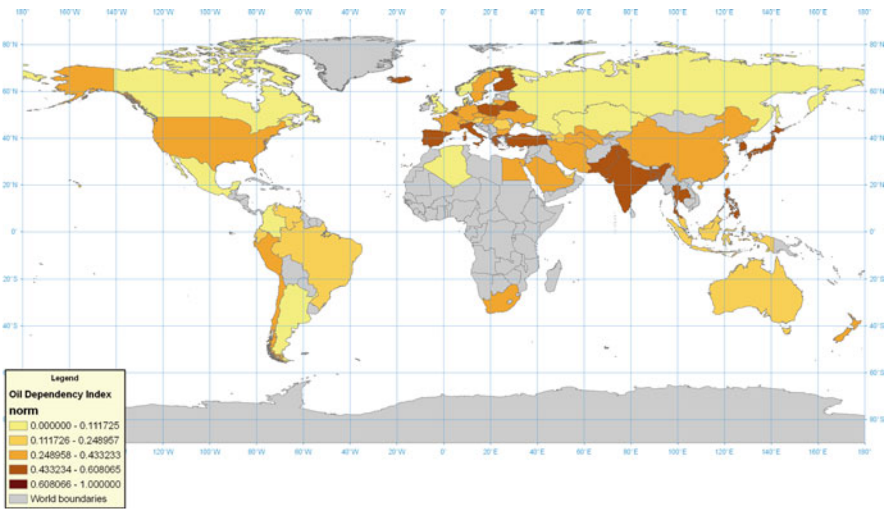

Fig. 28.4 Dependency on oil

exporting countries: Ecuador, UAE, and Qatar. Those that are diverse according to the index include parts of Europe (Finland, Bulgaria, Romania, and Germany), but also Japan and the United States.

28.5 Conclusions

Table 28.1 synthesizes the results of the analysis and sorts out nations based on how they rank in terms of oil import vulnerability and dependency on oil. More specifically, the table shows which nations ranked in the top 25% (high) and/or bottom 25% (low) for vulnerability and the same for oil dependency. We refer to these nations as energy security outliers. Nations that are at the greatest risk of being adversely affected by an oil supply disruptions are Japan and Ukraine. On the other hand, relatively immune nations include Norway and Mexico. While the vulnerability of a supply disruption is high for countries like Canada, Russia and Kazakhstan, a disruption is not likely to adversely affect their economies because they are not oil-dependent. Further, nations that are oil dependent, but not vulnerable, are less likely to be negatively impacted by supply shocks as a result of instability in an exporting nation. However, countries that fall into this category like Turkey and Portugal are not necessarily immune to global oil price shocks produced by violence, terrorism or military aggression. An understanding of this can help in anticipating where different geopolitical events will have their greatest impact and how the nature of the impact varies by country and region). This can provide a mechanism to see where disruption of oil infrastructure can have the greatest impact and also where investment into alternative energy megaengineering projects could reduce risk and vulnerability.

Further insight is gained by the finding that import vulnerability and oil dependency suggest some evidence of regional clustering. In particular, the most vulnerable nations are concentrated largely in the Former Soviet Union and large parts of Asia and Europe are dependent on oil. There is also some clustering in

Table 28.1 Energy security outliers

		Dependency	
		Low	High
Vulnerability	Low	Mexico Norway	Turkey Portugal Switzerland Iceland Philippines South Korea Azerbaijan Ecuador
	High	Kazakhstan Russia Canada	Japan Ukraine

the case of the components that go into the two composite indices. Some of these include net imports to consumption, reliance on top exporters, energy diversity and import diversity adjusted for the political instability of exporters. Yet, some indicators do not show a spatial association and there are countries for each of the indices that may be viewed as spatial outliers, for example, the United States in terms of vulnerability. These findings have a couple of implications for the development and implementation policies intended to minimize the adverse effects on geopolitical tensions on the energy market and on regional economies. The results of the analysis suggest that for some nations coordinated regional approaches are needed to address energy security concerns. In particular, nations located in regions that are generally susceptible to supply shocks from geopolitical events could benefit from forming or strengthening regional partnerships aimed at reducing those vulnerabilities. Regional collaboration could be useful in negotiating with other countries to construct a new pipeline that would help in diversifying transportation routes and lessening the importance of oil transshipment choke points. In contrast to this, reducing a country's *dependence* on foreign oil dictates more localized strategies, such as those that are targeted at increasing producing from domestic oil fields, maximizing refinery output and diversifying energy supply.

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