Is There an Oil Weapon?: Security Implications of Changes in the Structure of the International Oil Market

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International Security, Volume 39, Number 3, Winter 2014/2015, pp. 152-189 (Article)

Published by The MIT Press

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Is there an oil weapon? Concern about the use of oil as an instrument of coercion has been central to state intervention in oil markets. Historically, the U.S. government sought to ensure access for domestic firms in the Middle East on national security grounds.[1] Current U.S. national security strategy identifies the importance of Middle Eastern oil production to the global oil market as justification for retaining a military presence in the region.[2] Conversely, rising U.S. oil production in the 2000s leads some analysts to propose that the United States should reduce its military presence in the Persian Gulf.[3]

Assessing the relationship between oil and coercion hinges on understanding whether states are capable of imposing significant costs on others by curtailing the supply of oil. Yet the theoretical tools used to analyze this problem reflect responses to price volatility in the 1970s by focusing on the production of crude oil. The most important long-term effect of the oil crises, however, was the fragmentation of the oil supply chain into a series of linked, but discrete, markets that are not controlled by any single actor or group of actors.

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The authors thank Eugene Gholz, Jennifer Lind, Robert McNally, Daryl Press, Paul Staniland, Caitlin Talmadge, Kenneth Vincent, and the anonymous reviewers for helpful comments. A previous draft of this article was presented at the Program on International Security Policy at the University of Chicago on November 6, 2012.

1. See U.S. Senate, Special Committee Investigating Petroleum Resources, *American Petroleum Interests in Foreign Countries: Hearing before the Special Committee Investigating Petroleum Resources*, 79th Cong., 1st sess. (Washington, D.C.: Government Printing Office [GPO], 1945).
2. The 2010 U.S. National Security Strategy lists "access to energy and integration of the region into global markets" as "important interests in the greater Middle East." See U.S. Government, *National Security Strategy* (Washington, D.C.: White House, May 2010), p. 24.
3. On the rise in U.S. oil production, see International Energy Agency (IEA), *World Energy Report 2012—Executive Summary* (Paris: Organization for Economic Cooperation and Development [OECD]/IEA, 2012), pp. 1–2. Ed Morse, global head of commodities research for Citigroup, notes that the rise in U.S. oil production means that the United States "will no longer be kowtowing to despotic rulers and feudal monarchs whose oil supply lines are crucial to other aspects of foreign policy." See Steve Levine, "The Era of Oil Abundance," *Foreign Policy*, July 17, 2013, http://www.foreignpolicy.com/articles/2012/07/17/the_era_of_oil_abundance. For an empirical analysis of the rise in U.S. oil production, see Llewelyn Hughes, "The Limits of Energy Independence: Assessing the Implications of Oil Abundance for U.S. Foreign Policy," *Energy Research & Social Science*, Vol. 3 (September 2014), pp. 55–64.

International Security, Vol. 39, No. 3 (Winter 2014/15), pp. 152–189, doi:10.1162/ISEC_a_00188

We develop a framework for assessing the potential for coercion at each stage of the oil supply chain. Our primary focus is on whether the oil market is sufficiently concentrated in a given segment to enable states, or firms, to impose significant costs on others, thus potentially forcing them to alter their behavior. We employ a single measure of market concentration—the Herfindahl-Hirschman Index (HHI)—to compare the potential for coercion within and across different market segments and over time. In addition, we discuss a number of characteristics of each oil market that can increase or decrease the potential for coercion not captured by this measure of market concentration.

We adopt a narrow approach in defining the potential for coercion—specifically, whether an actor or a group of actors has the ability to force a sustained reduction in the supply of crude oil or crude products on a state. This definition focuses on the core concern of states: whether final products such as gasoline and diesel will not be available.[4] Also, it avoids any ambiguity associated with the incorporation of price.[5] It contrasts with approaches that expand the definition of energy security to incorporate the economic implications of price shocks, sustainability, and other issues.[6]

We highlight two findings from our analysis. First, the potential for coercion varies significantly across different stages of the oil supply chain and across time. This finding demonstrates the importance of monitoring changes in the potential for coercion across different market segments.[7] Second, although

4. Dale C. Copeland writes, "States concerned about security will dislike dependence, since it means that crucial imported goods could be cut off during a crisis. This problem is particularly acute for imports like oil and raw materials . . . without them most modern economies would collapse." See Copeland, "Economic Interdependence and War: A Theory of Trade Expectations," *International Security*, Vol. 20, No. 4 (Spring 1996), p. 10. Bassam Fattouh notes that the "conjunction of the concepts of oil dependency and vulnerability to serious disruptions in oil supplies constitutes the basis for energy security concerns." See Fattouh, "How Secure Are Middle East Oil Supplies?" Oxford Institute for Energy Studies WPM 33 (Oxford: Oxford Institute for Energy Studies, September 2007), p. 7.

5. The definition of energy security adopted by member states of the IEA includes the concept of affordability, for example, yet it is unclear how to meaningfully define affordability as it varies among and within states. See Fattouh, "How Secure Are Middle East Oil Supplies?" p. 7.

6. For more comprehensive approaches, see Benjamin K. Sovacool and Ishani Mukherjee, "Conceptualizing and Measuring Energy Security: A Synthesized Approach," *Energy*, Vol. 36, No. 8 (August 2011), pp. 5343–5355; and Securing America's Future Energy and Roubini Global Economics, *Oil Security Index* (New York: Securing America's Future Energy and Roubini Global Economics, October 2013).

7. A RAND study notes, "Oil industry research, analyses, and policy dialogs . . . tend to emphasize . . . upstream crude oil exploration and production. Much less analysis and discussion is devoted to oil companies as the downstream manufacturers." See D.J. Peterson and Sergej Mahnovski, "New Forces at Work in Refining: Industry Views of Critical Business and Operations

data show that the oil supply chain has tended toward less market concentration over time, the United States remains capable of wielding oil as a weapon through its dominance in naval power. As a result, tensions associated with managing responses to the potential for coercion in the maritime environment will remain the most important security issue in the coming decades.

Our article contributes to the understanding of the relationship between oil and international security in two ways. First, we incorporate into a single analytic framework a diverse literature that identifies a relationship between the structure of oil markets and the potential for states—or national oil companies—to coerce others.[8] Rather than focusing purely on oil production, or viewing oil as a single, globalized market, our framework analyzes the physical oil market as a series of discrete but interrelated markets. The framework can be readily extended to other nonrenewable resources with different market structures, including natural gas and coal, to identify their relevance for national security.

Second, and more generally, the article contributes to scholars' understanding of the relationship between changes in the organization of economic production and international security. Early theorizing about the implications of trade and the likelihood of conflict between states proposed an inverse relationship between trade and conflict as economic interdependence increases. More recent studies theorize about the implications of changes in the organization of production for international security; in particular, some scholars argue that the geographic dispersion of production and the fragmentation of the supply chain in defense industries make it harder for states to benefit from initiating war.[9]

Trends" (Santa Monica, Calif.: RAND Corporation, 2003), p. 5. Daniel Yergin also emphasizes the importance of ensuring "the security of the entire supply chain." See Yergin, "Ensuring Energy Security," *Foreign Affairs*, Vol. 85, No. 2 (March/April 2006), pp. 69–82.

8. For recent contributions, see John M. Deutch and James R. Schlesinger, "National Security Consequences of U.S. Oil Dependency" (New York: Council on Foreign Relations, 2006); Keith Crane et al., "Imported Oil and U.S. National Security" (Santa Monica, Calif.: RAND Corporation, 2009); Eugene Gholz and Daryl G. Press, "Protecting 'The Prize': Oil and the U.S. National Interest," *Security Studies*, Vol. 19, No. 3 (July/September 2010), pp. 453–485; Rosemary A. Kelanic, "Black Gold and Blackmail: The Politics of International Oil Coercion," Ph.D. dissertation, University of Chicago, 2012; Llewelyn Hughes and Phillip Y. Lipscy, "The Politics of Energy," *Annual Review of Political Science*, Vol. 16, No. 1 (May 2013), pp. 449–469; Jeff D. Colgan, "Fueling the Fire: Pathways from Oil to War," *International Security*, Vol. 38, No. 2 (Fall 2013), pp. 147–180; Charles L. Glaser, "How Oil Influences U.S. National Security: Reframing Energy Security," *International Security*, Vol. 38, No. 2 (Fall 2013), pp. 112–146; Michael Levi, "The Enduring Vulnerabilities of Oil Markets," *Security Studies*, Vol. 22, No. 1 (January/March 2013), pp. 132–138; and Eugene Gholz and Daryl G. Press, "Enduring Resilience: How Oil Markets Handle Disruptions," *Security Studies*, Vol. 22, No. 1 (January/March 2013), pp. 139–147.

9. Stephen G. Brooks, *Producing Security: Multinational Corporations, Globalization, and the Changing*

Our analysis suggests, however, that the relationship between national security and the reorganization of global supply chains is more complicated. In particular, it suggests that the potential for coercion can vary across discrete but interrelated markets that make up the supply chain for different goods. Indeed, the nationalization of oil production by governments in the Middle East and North Africa mattered to major consumer states primarily because it fragmented a supply chain once dominated by a small number of vertically integrated firms headquartered in Europe and the United States. Although the costs that can potentially be imposed on consumers as a result of the lack of competitive substitutes in the transportation sector may make oil *sui generis*, the case of oil suggests that the fragmentation of supply chains has the potential to impose costs across a broader array of products and industries.

It is important to note what the article does not set out to accomplish. It does not present a summary of the multiple mechanisms through which oil may generate national security externalities, such as providing funding for violent nonstate actors or harming governance in oil-export dependent states.[10] It also does not assess whether attempts to use oil as an instrument of coercion have succeeded historically. The ability to impose costs is a necessary, but not sufficient, condition for successful coercion; for example, the ability of targeted states to absorb costs also matters, but that issue is not addressed here.[11] Finally, the article does not examine in detail the structure of financial markets that are crucial to price setting and trade settlement in the international oil market.[12] Instead, we present a framework that facilitates a comparative analysis of the potential coercive risks across the physical oil supply chain, from production to transportation, refining, and distribution.

The article proceeds in four sections. The first section summarizes the existing literature on the relationship between oil and coercion. The second describes changes in the structure of the international oil market since the 1970s

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Calculus of Conflict (Princeton, N.J.: Princeton University Press, 2007). But see Eugene Gholz, "Globalization, Systems Integration, and the Future of Great Power War," *Security Studies*, Vol. 16, No. 4 (October/December 2007), pp. 615–636.

10. For this approach, see Colgan, "Fueling the Fire"; and Glaser, "How Oil Influences U.S. National Security."

11. For one assessment of cases from the 1970s, see Roy Licklider, *Political Power and the Arab Oil Weapon: The Experience of Five Industrial Nations* (Berkeley: University of California Press, 1988). On the difficulties of assessing the ability to use economic instruments to coerce, see Jonathan Kirshner, "The Microfoundations of Economic Sanctions," *Security Studies*, Vol. 6, No. 3 (Spring 1997), pp. 32–64.

12. In avoiding examination of financial markets, we assume that states are willing to absorb costs associated with price volatility. In the conclusion, we discuss the implications of relaxing this assumption.

and outlines a framework that distinguishes the degree of market power—from which potential coercive power emerges—across different stages of the petroleum supply chain. The third section uses this framework to discuss the national security problems that emerge from the exercise of market power in each of these stages. The article concludes with a discussion of the policy implications of the analysis.

The Literature on Oil and Coercion

States treat oil differently from other goods for two reasons. First, material capabilities are crucial to national security, and products derived from oil are crucial to material capabilities.[13] Oil holds the largest share of the total primary energy supply across most of the advanced industrialized economies, although the share of oil products has fallen as governments have promoted partial substitutes to oil products in electricity generation and other areas. Most obviously, oil products dominate the transport sector, where there are few competitive substitutes for gasoline and diesel.[14]

Second, oil differs from manufactured goods because geology determines the location of production. The result is increased state uncertainty about the exhaustibility of oil and whether states or firms can impose sufficient costs through the manipulation of supply to coerce others. Historical evidence shows that states have invested in strategies to manage the perceived risks of coercion: prior to World War II, for example, European states and firms sought to weaken U.S. firms' dominance in the international oil market by promoting the development of domestic refining infrastructure.[15] Conversely, the dominant market share of non-U.S. firms Royal Dutch Shell and British Petroleum outside the United States led the U.S. Senate to investigate discrimination against U.S. firms in the exploration, development, and production of crude oil.[16] Hans

13. Charles L. Glaser, *Rational Theory of International Politics: The Logic of Competition and Cooperation* (Princeton, N.J.: Princeton University Press, 2011).
14. John C.B. Cooper finds that the demand for crude oil is inelastic to changes in price across a large sample of countries. See Cooper, "Price Elasticity of Demand for Crude Oil: Estimates for 23 Countries," *OPEC Review*, Vol. 27 (March 2003), pp. 1–8.
15. On the French case, see Gregory P. Nowell, *Mercantile States and the World Oil Cartel, 1900–1939* (Ithaca, N.Y.: Cornell University Press, 1994).
16. U.S. Department of State, "Message from the President of the United States Transmitting in Response to Senate Resolution No. 149 of February 13, 1924: A Report of the Secretary of State Relative to the Diplomatic Correspondence in Connection with Securing Oil Concessions for American Citizens between This Government and the Governments of Certain Foreign Countries Regarding Oil Concessions in Those Countries" (Washington, D.C.: GPO, 1924).

Morgenthau identified the abundance of oil in the United States and the Soviet Union as a core reason for their dominance during the Cold War.[17]

Theorizing about the relationship between oil and coercion stagnated in the 1980s, when oil prices remained relatively low.[18] More recently, scholars have begun to reexamine the relationship between oil and international security. This body of work can be organized into three types. The first identifies multiple pathways through which oil affects important outcomes in international security. Keith Crane et al., for example, identify eight causal mechanisms that they propose link oil to U.S. national security, including supply disruptions, competition between oil-consuming states, and oil export revenues being used to finance terrorism. Charles Glaser identifies six causal pathways through which changes in oil supply and demand might impair U.S. national security. Jeff Colgan identifies eight mechanisms that relate oil to interstate conflict more generally, including the influence of economic rents generated by oil in producer countries in increasing the risk of civil conflict within those countries, as well as the negative effect of oil on governance.[19]

A second family of theories focuses more closely on the relationship between oil and coercion. Rose Kelanic, for example, argues that geographic vulnerability, relative military power, and import dependence contribute to the susceptibility of states to coercion.[20] Studies by Eugene Gholz and Daryl Press, and Andreas Goldthau and Jan Martin Witte, find that oil imports provide little coercive leverage, because the international oil market is integrated.[21]

Analyses of the risks of conflict with Iran echo this conclusion, finding that Iran has a limited ability to cause a significant disruption to oil supplies through military action in the Strait of Hormuz or through attacks on Saudi oil infrastructure.[22] These studies conclude that although Iran has some potential

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17. Hans J. Morgenthau, *Politics among Nations: The Struggle for Power and Peace* (New York: Alfred Knopf, 1960). Following the oil shocks of the 1970s, Morgenthau observed that the importance of oil was such that "there is no halfway house from which one can destroy the stranglehold which the oil-producing nations have on the oil-consuming ones. Either one submits to the pressure, or one goes to war." See Morgenthau, "World Politics and the Politics of Oil," in Gary D. Eppen, ed., *Energy: The Policy Issues* (Chicago: University of Chicago Press, 1975), p. 115.
18. Hughes and Lipscy, "The Politics of Energy," p. 9.
19. Crane et al., "Imported Oil and U.S. National Security"; Glaser, "How Oil Influences U.S. National Security"; and Colgan, "Fueling the Fire."
20. Kelanic, "Black Gold and Blackmail."
21. Gholz and Press, "Protecting 'The Prize'"; and Andreas Goldthau and Jan Martin Witte, "Back to the Future or Forward to the Past? Strengthening Markets and Rules for Effective Global Energy Governance," *International Affairs*, Vol. 85, No. 2 (March 2009), p. 375. But see Levi, "Enduring Vulnerabilities."
22. Joshua R. Itzkowitz Shifrinson and Miranda Priebe, "A Crude Threat: The Limits of an Iranian

to disrupt oil flows, such disruptions would be temporary and highly dependent on Iranian surprise. If the United States and its Gulf allies detected Iranian efforts before they were fully implemented, then the level of disruption could be minimal. U.S. naval and air assets in these early detection scenarios would overwhelm Iranian capabilities to block the strait, and at present Saudi infrastructure is too difficult a target for Iranian strike assets.

A third body of work examines the degree to which the Organization of the Petroleum Exporting Countries (OPEC) influences oil prices and the effect this has on economic performance in the major oil-consuming states. In doing so, it links the study of oil and security to concerns about economic welfare.[23] The impact of oil price shocks on U.S. economic performance is a matter of dispute, but many analysts find a weakened relationship between increases in oil prices and output. William Nordhaus, for example, argues that "the main thing we have to fear about oil-price shocks is the fearful overreactions of the monetary authority, consumers, businesses, and workers," rather than the shock itself.[24] Some analysts argue that OPEC has little influence over oil prices, in part because member states have incentives to ignore production quotas.[25]

Missile Campaign against Saudi Arabian Oil," *International Security*, Vol. 36, No. 1 (Summer 2011), pp. 167–201; Caitlin Talmadge, "Closing Time: Assessing the Iranian Threat to the Strait of Hormuz," *International Security*, Vol. 33, No. 1 (Summer 2008), pp. 82–117; and Eugene Gholz et al., "Threats to Oil Flows through the Strait of Hormuz," University of Texas at Austin, March 2010.

23. Douglas R. Bohi and Michael A. Toman define energy security as inversely proportional to "the loss of economic welfare that may occur as a result of a change in the price or availability of energy." See Bohi and Toman, *The Economics of Energy Security* (Dortrecht, Netherlands: Kluwer Academic, 1996), p. 1. The Congressional Budget Office defines energy security as "the ability of U.S. households and businesses to accommodate disruptions of supply in energy markets." See Congressional Budget Office, "Energy Security in the United States" (Washington, D.C.: Congressional Budget Office, May 2012). The definition has expanded over time, from a focus on military preparedness to the resilience of the civilian economy. See Bohi and Toman, *The Economics of Energy Security*, pp. 2–3.

24. William D. Nordhaus "Who's Afraid of a Big Bad Oil Shock?" Brookings Papers on Economic Activity (Washington, D.C.: Brookings Institution, Fall 2007), pp. 219–238, at p. 237. See also Olivier Blanchard and Jordi Gali, "The Macroeconomic Effects of Oil Shocks: Why Are the 2000s So Different from the 1970s?" National Bureau of Economic Research Working Paper No. W13368 (Cambridge, Mass.: National Bureau of Economic Research, 2007). Hillard G. Huntington summarizes, "[A] ten percent increase in crude oil prices will cause the Gross Domestic Product level to be between 0.2 and 0.5 percent lower than otherwise after six quarters." See Huntington, "The Oil Security Problem," Stanford University Energy Modelling Forum Working Paper, EMP OP 62 (Stanford, Calif.: Stanford University, February 2008), p. 22. See also James D. Hamilton, "Oil and the Macroeconomy," in S.N. Durlauf and L.E. Blume, eds., *The New Palgrave Dictionary of Economics Online*, 2nd ed. (Basingstoke, U.K.: Palgrave Macmillan, 2008), http://www.dictionaryofeconomics.com/dictionary; and Lutz Kilian, "Exogenous Oil Supply Shocks: How Big Are They and How Much Do They Matter for the U.S. Economy?" *Review of Economics and Statistics*, Vol. 90, No. 2 (May 2008), pp. 216–240.

25. The literature on the role of OPEC in price setting is voluminous. For a review, see Bassam

Analyzing the Potential for Coercion in the Oil Market

The relatively sanguine view about the relationship between oil and coercion described above emerges from the assertion that the oil market is "one great pool."[26] In this view, supply shocks in an integrated oil market are experienced as price phenomena that have economic effects, but that are unlikely to confer coercive power to any single actor or group of actors.

Treating oil as a single market, however, does not account for the separation of the physical supply chain into a series of related but discrete segments: from production, to transportation, to refining and distribution. This fragmentation of the supply chain implies that the potential for coercion can vary across market segments and that this potential can change over time. It also implies that the actor or actors capable of coercion may vary across different stages of the supply chain. The most appropriate method for analyzing the potential for coercion is thus to examine the structure of the discrete markets that constitute the oil supply chain and the nature of the linkages among them.

The oil supply chain has always comprised a series of segments. Prior to the 1970s, however, these segments were integrated into a small number of international oil companies (IOCs), which controlled the production of crude oil outside Canada, Mexico, the Soviet Union, and the United States, and also dominated refining and distribution.[27] The most important long-term effect of the loss of control over production decisions by the IOCs was the frag-

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Fattouh and Lavan Mahadeva, "OPEC: What Difference Has It Made?" *Annual Review of Resource Economics*, Vol. 5 (2013) pp. 427–443. See also James L. Smith, "Inscrutable OPEC? Behavioral Tests of the Cartel Hypothesis," *Energy Journal*, Vol. 26, No. 1 (2005), pp. 51–83. Hillard Huntington et al. note that the behavior of OPEC is poorly understood. See Huntington et al., "Oil Price Drivers and Movements: The Challenge for Future Research," *Alternative Investment Analyst Review*, Vol. 2, No. 4 (Winter 2014), pp. 11–28. Lisa Blaydes asserts that OPEC performs poorly as a cartel. See Blaydes, "Rewarding Impatience: A Bargaining and Enforcement Model of OPEC," *International Organization*, Vol. 58, No. 2 (March 2004), pp. 213–237. Jeff Colgan argues that members of OPEC gain political rather than economic goals from participation. See Colgan, "The Emperor Has No Clothes: The Limits of OPEC in the Global Oil Market," *International Organization*, Vol. 68, No. 3 (Summer 2014), pp. 599–632.

26. For this view, see Robert J. Weiner, "Is the World Oil Market 'One Great Pool?'" *Energy Journal*, Vol. 12, No. 3 (1991), pp. 95–108; and Morris A. Adelman, "Is the World Oil Market 'One Great Pool?'—Comment," *Energy Journal*, Vol. 13, No. 1 (1992), pp. 157–158. Philip K. Verleger Jr. offers an early presentation of the view of oil as a commodity. See Verleger, "The Evolution of Oil As a Commodity," in Richard L. Gordon, Henry D. Jacoby, and Martin B. Zimmerman, eds., *Energy: Markets and Regulation—Essays in Honor of M.A. Adelman* (Cambridge, Mass.: MIT Press, 1987), pp. 161–186.

27. A 1952 investigation by the U.S. Federal Trade Commission found that this set of firms controlled approximately 92 percent of reserves outside these countries in 1949 and 88 percent of non-U.S. and Soviet production, as well as 77 percent of non-U.S. and Soviet refining capacity. See

Table 1. Balance of Oil Production and Refining Capacity for Major Oil-Producing Firms

		(unit: 1000s barrels/day)		
Type	Firm	Production (A)	Refining (B)	A-B
IOC	Petrochina	2,350	2,476	−127
IOC	BP	2,157	2,679	−522
IOC	Shell	n.a.	n.a.	n.a.
IOC	Chevron	1,849	1,787	62
IOC	Total	1,226	2,090	−864
IOC	ConocoPhillips	799	2,166	−1,367
NOC	National Iranian Oil	4,054	1,451	2,603
NOC	Saudi Aramco	9,458	2,080	7,378
NOC	Petroleon de Venezuela	2,240	1,282	958
NOC	Qatar General Petroleum Corp	1,295	339	956
NOC	Iraq National Oil Corp	2,625	638	1,987
NOC	Abu Dhabi National Oil Corp	2,687	773	1,914
NOC	Kuwait Petroleum Corp	2,530	936	1,594
NOC	Nigerian National Petroleum Corp	2,525	445	2,080
NOC	National Oil Company Libya	465	378	87
NOC	Sonatrach	1,540	450	1,090
NOC	Gazprom	1,004	813	190
NOC	Rosneft	2,322	1,022	1,299
NOC	Egyptian General Petroleum Corp	564	726	−162
NOC	Pemex	2,959	1,540	1,419
NOC	Lukoil	1,940	1,476	464
NOC	Petroleo Brasilerio	2,105	1,908	197
NOC	Sonangol	1,785	39	1,746
NOC	Petroleum Development Oman	885	85	800
		Estimated Externally Traded Oil		26,600

NOTE: IOC refers to an international oil company; NOC refers to a national oil company; data for national oil companies are drawn from country briefs from the Energy Information Agency; data for Gazprom, Rosneft, and Lukoil are drawn from company accounts; tonnes converted to barrels at 7.33 conversion rate; Lukoil data for 2010; data for Shell are not included as production data not broken down for oil and natural gas.

mentation of the oil supply chain. The amount of oil traded on external markets—rather than within vertically integrated firms—can be calculated as the difference between total oil production and refinery throughput at the most important national oil companies, which produce oil largely within the home country, and at the major IOCs.[28] Table 1 suggests that a mean of 26.6 million barrels of oil per day (mbd) was traded on external markets in

Federal Trade Commission, *The International Petroleum Cartel—Staff Report to the Federal Trade Commission* (Washington, D.C.: Federal Trade Commission, 1952), pp. 23–24.

28. Here we follow Leonardo Maugeri, *The Age of Oil: The Mythology, History, and Future of the World's Most Controversial Resource* (New York: Praeger, 2006).

2011.[29] This figure represents almost 70 percent of total oil exported globally.[30] But it probably underestimates the amount of oil available to be traded on external markets, because IOCs such as BP, Exxon, Shell, and Total allow business units to sell both crude oil and refined products outside their firms, increasing the total amount of oil and oil products available through external markets.[31]

This fragmentation of the oil supply chain extends to the midstream. The major oil producers historically owned tanker capacity sufficient to meet long-term demand, chartering ships to match seasonal demand fluctuations. The loss of control over production decisions following the nationalizations of the 1970s led them to further reduce their number of tankers. In 1976 the IOCs controlled 194 of the world's 636 oil tankers of 200,000 deadweight tonnes (DWT) and above (30.5 percent), but by 1996 this figure had fallen to 63 of the world's 447 tankers (14.1 percent).[32]

Theoretically, the fragmentation of the oil market into multiple segments increases the robustness of the supply chain by expanding the number of potential suppliers. This is contingent, however, on the number of actors operating within a single segment. If refining capacity or tanker tonnage is concentrated in a single entity, for example, a greater potential exists to impose significant costs by limiting supplies in that segment. The potential for an actor to impose significant costs falls, on the other hand, as the market share concentrated in a single actor falls.

How, then, should we analyze the potential for coercion, given the fragmentation of the oil supply chain? In table 2 we present a framework for analyzing

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29. Calculated by the authors as the net of production minus refinery capacity for National Iranian Oil, Saudi Aramco, Petroleum de Venezuela, Qatar General Petroleum Corp, Iraq National Oil Corp, Abu Dhabi National Oil Corp, Kuwait Petroleum Corp, Nigerian National Petroleum Corp, National Oil Company Libya, Sonatrach, Gazprom, Rosneft, Egyptian General Petroleum Corp, Pemex, Lukoil, Petroleo Brasilerio, Sonangol, and Petroleum Development Oman. Data for national oil companies are drawn from country briefs from the Energy Information Administration (EIA), http://www.eia.gov/countries/. Data are from 2011. Additional information on Abu Dhabi Oil Corp, Gazprom, Rosneft, and Lukoil is drawn from company annual reports. Lukoil data are for 2010. Metric tonnes converted to barrels at 7.33 to 1 conversion rate.

30. We calculated the ratio of "surplus" oil to total oil exported using figures for total crude oil exports from "Oil: Imports and Exports," in British Petroleum (BP), *BP Statistical Review of World Energy 2012* (London: BP, 2012).

31. Majed A. Al-Moneef, "Vertical Integration Strategies of the National Oil Companies," *Developing Economies*, Vol. 36, No. 2 (June 1998), pp. 203–222; and Nick Antill and Robert Arnott, *Oil Company Crisis: Managing Structure, Profitability, and Growth* (Oxford: Oxford Institute for Energy Studies, 2003).

32. Michael D. Tusiani, *The Petroleum Shipping Industry: A Nontechnical Overview*, Vol. 1 (Tulsa, Okla.: Penwell, 1996).

Table 2. Oil Markets and the Potential for Coercion

Segment	Market Concentration		Expected Importer State Responses
	Degree	Scope	
Upstream—Exploration & Production	unconcentrated/ somewhat concentrated*	global	more limited state intervention
Midstream—Maritime (Commercial)	unconcentrated	global	more limited state intervention
Midstream—Maritime (Military)	highly concentrated	global	military balancing
Downstream—Refining & Distribution	unconcentrated	national/ regional/ global	more limited state intervention

*By country/OPEC as a single unit.

NOTE: The last column records expected policy responses by major importer states for each stage of the supply chain.

the relationship between oil and coercion. Dividing the oil supply chain enables comparison of the potential for coercion within different segments. It leaves the problem, however, of how to measure variation in coercive potential across market segments. We employ a simple measure of market concentration—the Herfindahl-Hirschman Index—as a first approximation of potential coercive power. The index offers a means to compare the potential for coercion in different market segments, as well as across time.[33] Conceptually, market concentration is related to the question of whether states or firms have the potential to coerce others: a high level of market concentration is a necessary condition for imposing significant costs, whereas a low level of market concentration reduces the ability to impose costs on others given the presence of alternative suppliers. In addition, using a single measure avoids the problem of sensitivity to weighting from which composite indices can suffer.[34]

Table 2 describes each market segment as "highly concentrated," "somewhat concentrated," or "unconcentrated," using the guidelines for mergers employed by the U.S. Department of Justice and the U.S. Fair Trade

33. The method was developed by Orris C. Herfindahl and Albert O. Hirschman independently. See Hirschman, "The Paternity of an Index," *American Economic Review*, Vol. 54, No. 5 (September 1964), p. 761.

34. For a discussion, see Enrico Giovannini et al., "Handbook on Constructing Composite Indicators: Methodology and User Guide," OECD Statistics Working Paper 2005/3 (Paris: OECD, 2005), pp. 31–35.

Commission.[35] This is a helpful, but imperfect, approximation for understanding the relationship between oil and coercion. These thresholds are designed to identify when market concentration affects the terms of competition. Evidence suggests that the willingness of states to resist attempts at coercion, on the other hand, is substantially higher.[36] Also, it is likely to vary depending on regime type and other domestic attributes of a state.[37]

Rather than adopting an arbitrary threshold beyond which we assert that market concentration confers the potential for coercive leverage, we chose to use a historical approach that compares levels of market concentration across market segments and within segments across time. Doing so enables us to identify which segments of the oil supply chain have greater potential to enable the imposition of significant costs than others. It also allows us to identify whether the ability to impose costs has increased or decreased over time.

One drawback of using a single measure of market concentration is that it does not take into account characteristics of particular market segments that might strengthen (or weaken) the ability to impose costs. In the case of oil production, for example, analysts identify spare capacity, privately held oil inventories, and strategic oil reserves as affecting the ability of single actors or groups of actors to impose costs on others. In the maritime environment, spare capacity matters for the commercial tanker market.[38] In addition, the effects of geography, technology, and surprise can increase (or decrease) the potential for military coercion in the midstream segment. In the downstream segment, refineries are structured to process particular types of oil, raising the question of whether the market for crude oil is as integrated as some analysts say it is.[39] We discuss the implications of a number of these characteristics below.

In addition, if we assume that states are unitary actors with perfect informa-

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35. Under this measure, 10,000 represents a perfect monopoly, whereas one represents perfect competition. Higher levels are thus associated with an increased ability to impose costs. The Federal Trade Commission determines market concentration as follows: "[M]arket concentration is ranked into three separate categories based on the HHI: a market with an HHI under 1,000 is considered to be unconcentrated; if the HHI is between 1,000 and 1,800 the market is considered moderately concentrated; and if the HHI is above 1,800, the market is considered highly concentrated."

36. A.F. Alhajji finds, for example, that attempts to use oil as a coercive tool in 1956, 1967, and 1973 failed. See Alhajji, "Three Decades after the Oil Embargo: Was 1973 Unique?" *Journal of Energy and Development*, Vol. 30, No. 2 (Spring 2005), pp. 223–237. See also Licklider, *Political Power and the Arab Oil Weapon*.

37. Kirshner, "The Microfoundations of Economic Sanctions."

38. For a discussion, see Levi, "Enduring Vulnerabilities"; and Gholz and Press, "Enduring Resilience."

39. For one assessment of this question in relation to China, see Inwook Kim, "Refining the Prize: Chinese Oil Refineries and Its Energy Security," *Pacific Review*, forthcoming.

tion, then one implication of our analysis is that the resources expended by states to manage the probability of coercion should vary by market segment, as well as over time.[40] Specifically, where market power is concentrated in a non-ally, major oil-importing states should increase the amount of resources they expend to manage the potential for coercion. When market concentration is low, on the other hand, these states can be expected to decrease the amount of resources used for this purpose. Thus changes in the level of market concentration within the upstream, midstream, and downstream segments should be reflected in policy changes implemented in the major oil-importing states.

The Potential for Coercion in Comparative, Historical Perspective

This section is organized by market segment. For each segment, we begin by examining the potential for coercion by measuring levels of market concentration in comparative, historical perspective. We then discuss important characteristics of each market segment that plausibly affect the potential for coercion. Finally, for each segment we outline common responses by major consumer governments in light of the expectations developed above. Although a full test of the range of policies implemented by states is beyond the scope of this article, typical state responses are discussed beginning with the upstream segment and then the midstream and downstream segments.

UPSTREAM—EXPLORATION AND PRODUCTION

Analyses of the potential for oil to be used for coercion commonly focus on the global distribution of reserves and production. Yet historical data show that the growth in the number of countries producing substantial volumes of crude oil has limited the potential for coercion. The number of countries producing 100,000 barrels a day or more increased from twenty-one to forty-three from 1965 to 2013, and the number of countries producing a million barrels a day increased from eight to nineteen over the same period.[41] This growth occurred across a geographically dispersed range of countries: South American countries such as Argentina, Brazil, Colombia, and Ecuador, plus Mexico, added at least 100,000 barrels per day to production levels from 1965 to 2013; in the Asia Pacific, producers in Australia, China, India, Malaysia, Thailand,

40. We thank an anonymous reviewer for this suggestion.
41. Countries within the former Soviet Union are treated as a single unit for the basis of comparison.

and Vietnam contributed at least 100,000 barrels per day over the same period. African supply also increased, with Algeria, Angola, Egypt, Gabon, Nigeria, the Republic of Congo, and Sudan adding at least 100,000 barrels per day of production from 1965 to 2013. In this sense, the enormous increase in oil production in the United States through the rise in shale oil production reflects the historical trend of oil production to become more dispersed over time.

This simple count of the number of countries producing substantial volumes of oil provides information about the diversification of oil supplies, but it fails to capture variation in the amount produced on a country-by-country basis. Including these data shows that market concentration has fallen in historical perspective, although it remains greater than in the refining and commercial shipping segments of the oil supply chain. This is also the case when treating the Middle Eastern producers within OPEC as a single unit, thus approximating the case in which a single state controls all oil in the Middle East.

Indeed, the most dominant producer historically is the United States, when measured on a country basis.[42] From 1918 to 1944, the period when oil was first identified as having important implications for national security, oil production was highly concentrated, with a mean level of 4,490, fluctuating between 3,804 and 5,441. Since 1965 it has varied between 559 and 1,405, when calculated using producer-state as the unit of analysis.[43] When OPEC is treated as a single unit, market concentration falls from 2,902 to 1,915 over the same period.[44]

As a first approximation, the dispersion of oil production globally thus suggests that the potential for coercion is low by historical standards. A second factor militating against the potential for coercion in the production segment is the ability of multiple actors to obtain a share of oil produced within some states. Commercial contracts in a number of states allow multiple firms to secure a share of production crude reserves from a given field.[45] An International Energy Agency assessment records 70,000 small oil fields responsible for

42. For the purposes of comparison, we use the state as the relevant unit of analysis for both the pre– and post–World War II periods. Prior to the 1970s, the most important actors across the supply chain were the IOCs. For details, see John M. Blair, *The Control of Oil* (New York: Vintage, 1978).
43. This is calculated using state production as the unit of analysis. An alternative strategy would be to focus on market concentration on a firm basis, given the domination of the major IOCs in the prewar period. For an analysis, see Federal Trade Commission, *The International Petroleum Cartel*.
44. Authors' calculations. Prewar data are drawn from DeGolyer and MacNaughton, *Twentieth Century Petroleum Statistics: Historical Data* (Dallas: DeGolyer and MacNaughton, 2000), p. 3. Postwar data are drawn from BP, *BP Statistical Review of World Energy 2012*.
45. Michael Likosky, "Contracting and Regulatory Issues in the Oil and Gas and Metallic Minerals Industries," *Transnational Corporations*, Vol. 18, No. 1 (April 2009), pp. 1–42.

approximately 50 percent of aggregate global production. It also records 798 fields with proven and provable reserves of at least 50 million barrels. Of these, thirteen oil fields produce more than 500,000 barrels per day, collectively representing 25 percent of global production.[46]

Many of the largest fields are located in states that significantly restrict, or do not allow, foreign direct investment in the oil sector. There are nevertheless forty-six super-giant and giant fields in North America, twenty-three in Europe, twenty in Asia, forty-one in Africa, and forty in Latin America. Although a state can expropriate a field regardless of the underlying terms of the commercial contract, the large number of states producing oil that also allow inward investment in oil fields makes it unlikely they will successfully coordinate to restrict production (see figure 1).[47] The diversification of suppliers on a field-by-field basis thus supports the claim that the international oil market is "liquid, competitive and truly global."[48] It also suggests that the ability of producers to impose significant costs, defined as a sustained reduction in the supply of crude oil or crude products to others, is low by historical standards.

The dispersion of production and investment does not mean that the oil market is perfectly competitive. An important feature of the upstream segment of the oil supply chain is the role of spare capacity in balancing global supply and demand for crude oil. In particular, Saudi Arabia's willingness to forgo selling crude oil that it has the capacity to produce gives it a role in setting the marginal price for oil when increased demand is not met by increases in production by fringe producers.[49] The relationship between spare capacity and oil prices is complicated, however. For example, low levels of spare capacity make it difficult for producers to respond quickly to increases in demand, putting upward pressure on oil prices. Meanwhile the incentive for oil producers to cheat increases along with rises in spare capacity, with the opposite effect. Most important, the primary effect of spare capacity is on oil prices, which is experienced by all market participants.

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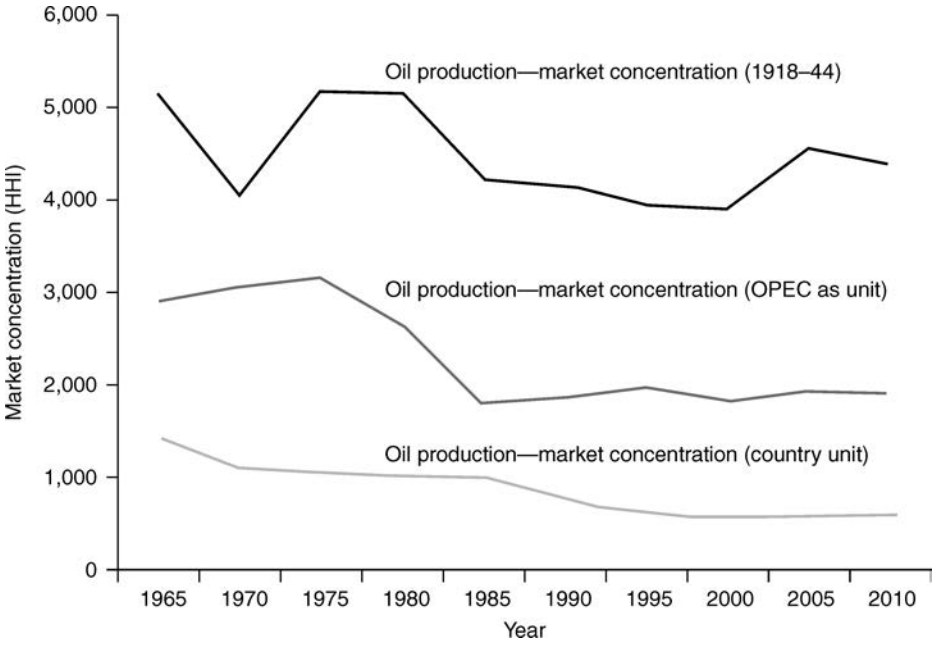
46. IEA, *World Energy Outlook 2008* (Paris: IEA, 2008), p. 222.
47. For a review of trends in expropriations, including in the oil sector, see Michael S. Minor, "The Demise of Expropriation As an Instrument of LDC Policy, 1980–1992," *Journal of International Business Studies*, Vol. 25, No. 1 (First Quarter 1994), pp. 177–188.
48. Authors' calculations. Data are drawn from BP, *BP Statistical Review of World Energy 2010* (London: BP, 2010), quoted in Goldthau and Witte, "Back to the Future or Forward to the Past?" p. 375.
49. The IEA defines spare capacity as "sustainable production capacity . . . which can be reached within 30 days and sustained for 90 days." Producers also underinvest in oil production facilities to affect supply. For a review of theoretical approaches toward understanding the role of Saudi Arabia within OPEC, see Fattouh and Mahadeva, "OPEC."

Figure 1. Market Concentration in Oil Production in Historical Perspective



NOTE: Pre-World War II data drawn from DeGolyer and MacNaughton, *Twentieth Century Petroleum Statistics Historical Data* (Dallas: DeGolyer and MacNaughton, 2000); data for 1965 onward from *BP Statistical Review of World Energy 2014* (London: BP, 2014).

Inventories held by private firms can provide an additional buffer against supply shortfalls. Total inventories within the United States, which include inventories of oil products in addition to crude oil, expanded available supplies to 971 million barrels in 1995, rising to nearly 1.07 billion barrels in 2010. In Europe, private stocks were estimated at more than forty days of consumption at the end of 2012.[50] Even if not fully available, the oil in private inventories is large relative to historical shortfalls in oil production: between 1951 and 2003,

50. Data are drawn from the EIA, "Petroleum and Other Liquids," http://www.eia.gov/petroleum/data.cfm. Lutz Kilian and Daniel P. Murphy note the lack of comprehensive data on crude oil inventories outside the United States. See Kilian and Murphy, "The Role of Inventories and Speculative Trading in the Global Market for Crude Oil," *Journal of Applied Econometrics*, Vol. 29, No. 3 (April/May 2014), pp. 454–478; and IEA, *Mid-Term Oil Market Report* (Paris: IEA, 2014), p. 114. On the relationship between private inventories and prices, see Gholz and Press, "Protecting 'The Prize,'" pp. 460–461.

the mean disruption was 1.3 mbd, with a mean length of 6.7 months. The most serious disruption occurred during the 1990–91 Gulf War, when 4.6 mbd of production was lost for twelve months. These inventories are also larger than those used in assessments of likely future disruptions.[51] In addition, member states of the International Energy Agency retain substantial petroleum reserves as a hedge against supply shortfalls, providing an additional buffer against the potential for coercion.[52]

upstream—oil importer responses

One empirical expectation of the analysis above is that a reduction in the potential for coercion should be associated with a reduction in responses to this risk in major oil-importing states, if we assume full information. Although we recognize that other factors can also influence states' oil sector policies, a probe of policy changes in the major oil-consuming states shows that the data are consistent with this expectation. In this sense, China's subsidization of domestic oil firms' exploration and production activities internationally stands in contrast to the trend away from active state intervention on energy security grounds.

In the 1980s and 1990s, governments in major oil-importing states privatized domestic oil firms. National oil companies headquartered in the major oil-importing states, including Deminex (Germany), ENI (Italy), OeMV (Austria), Petrofina (Belgium), Petrogal (Portugal), Repsol (Spain), Svenska Petroleum Exploration (Sweden), and Total (France), were fully or partially privatized.[53] The change in state strategies designed to manage risk in the production segment of the oil supply chain was codifed in 1993 in the Shared Goals agreed to by member states of the International Energy Agency. The Shared Goals promote diversification and greater energy efficiency as the best ways to increase energy security, and advocate for "free and open trade and a secure framework for investment."[54] The change toward a less interventionist approach is

51. Phillip C. Beccue and Hillard G. Huntington estimate the risk of oil market disruptions in terms of duration and size, finding a low probability of larger, lengthier disruptions. See Beccue and Huntington, "An Assessment of Oil Market Disruption Risks," Energy Modeling Forum SR 8 (Palo Alto, Calif.: Stanford University, October 2005), p. 55. For a more pessimistic assessment, see Robert McNally, "Managing Oil Market Disruption in a Confrontation with Iran" (New York: Council on Foreign Relations, January 2012).
52. The distinction between private inventories and strategic oil reserves is blurred in practice, as some countries mandate that firms retain stocks as part of their strategic reserves policy.
53. This section is drawn from Llewelyn Hughes, *Globalizing Oil: Firms and Oil Market Governance in France, Japan, and the United States* (Cambridge: Cambridge University Press, 2014).
54. IEA, "Shared Goals," June 4, 1993, http://www.iea.org/aboutus/whatwedo/sharedgoals/.

also consistent with expectations, given the reduced potential for coercion in the upstream segment of the oil supply chain.

A second strategy focuses on finding alternatives to oil and reducing the intensity of energy usage. Governments in the major oil-importing states continue to invest in these areas, in part because they also promote climate change–related public policy goals. Data show that investments in these areas have nevertheless declined as a share of national income across the most important oil-importing countries. Figures from the International Energy Agency's Energy Technology Research, Development, and Demonstration Database, for example, record changes in state investments in energy efficiency, fossil fuels, renewable energy sources, nuclear fission and fusion, and hydrogen and fuel cell technology.[55] These data show that public investment in these areas fell as a share of national income across the major oil-importing states, an outcome that is also consistent with expectations following the reduction in coercive risk in the international oil market.[56]

MIDSTREAM—MARITIME (COMMERCIAL)

How does the upstream segment compare with the midstream segment in the oil supply chain? In this section, we focus on the oil tanker market.[57] The importance of tankers to the oil trade means that a state or firm with the capability of impeding shipping either through the exercise of market power in the commercial shipping market or through military means could gain coercive leverage over others.

Similarly to crude oil production, historical data drawn from tanker registries show that market concentration within the commercial tanker market has varied over time, but is lower today than in earlier periods. In 1915, when oil products dominated ocean-borne trade, companies associated with the IOCs owned 53 percent of a global total of 465 tankers in service, with governments controlling just 2 percent of this fleet. After World War I, the market share of IOC-related firms remained stable, even as the total number of tankers in-

55. Spending on fossil fuels is less than 1 percent of total spending across all countries examined.
56. The data underpinning this statement are drawn from the IEA's Energy Technology RD&D Database, http://www.oecd-ilibrary.org/energy/data/iea-energy-technology-r-d-statistics_enetech-data-en, normalized to inflation-adjusted gross domestic product. The data cover France, Germany, Italy, Japan, Spain, the United Kingdom, and the United States for the 1975–2009 period.
57. In 2009 two-thirds of the 53 million barrels of oil traded internationally were shipped by tanker. See Al Wood, "Tanker Ownership in Non-OECD Countries and the Rise of Government-Owned Fleets," Working Paper IIEP-WP-2011-07 (Washington, D.C.: Institute for International Economic Policy, George Washington University, August 2011), p. 1.

creased to 598. In contrast, the number of tankers directly owned by governments increased to almost 28 percent of the total tanker market.

A large part of this increase in government ownership stemmed from the rise in the number of tankers controlled by the British Admiralty from 3 to 32. By the 1930s, in contrast, both the IOCs and governments shed tanker capacity, which fell to 29.4 percent and 5.8 percent of total tankers, respectively. World War II saw an increase in the number of tankers directly controlled by governments. By 1946, firms associated with the IOCs owned 465 of the world's inventory of 2,667 tankers, or 17.4 percent of the total market, while governments expanded ownership to 1,219 tankers, or 45.7 percent of the total market. Much of this expansion reflected the entry into the tanker market by different agencies of the U.S. government: the U.S. Maritime Commission controlled 621 tankers, the U.S. Navy 250, and the U.S. War Department 108.[58]

These changes are reflected in the overall market concentration of tankers. If we calculate IOC-related firms as a single actor, market concentration increased from 2,845 in 1915 to 3,193 in 1920, and varied between 885 and 1,691 from 1934 to 1946. The degree of market concentration was thus lower than it was for the production segment of the supply chain in the prewar period.

The commercial tanker market remained relatively unconcentrated in the postwar period. The measure of market concentration employed here rose from 1,340 in 1980 to 1,778 in 1984, when calculated using the state as the unit of analysis and using the DWT of flagged vessels. The degree of concentration is thus higher than in the upstream segment but lower than when market concentration is calculated treating OPEC as a single actor. By 2013, market concentration had fallen to 506, significantly lower than in the upstream segment, and lower than in previous periods. The largest ship owner, Mitsui OSK, held a 7.6 percent market share when calculated using DWTs.[59] Taken together,

58. Data calculated by authors using Standard Oil Company (New Jersey), *Register of Tank Vessels for Carrying Petroleum Products Etc*. (New York: A.S. Roe, June 1915); Standard Oil Company (New Jersey), *Tank Steamer Register* (New York: R.L. Hague, 1920); Standard Oil Company (New Jersey), *Register of Tank Vessels for Carrying Petroleum Products Etc*. (New York: R.L. Hague, 1934); and Standard Oil Company (New Jersey), *Register of Tank Vessels of the World* (New York: M.G. Gamble, 1946). The registers record all vessels of 300 gross tons or above. The calculations made here do not take into account differences in deadweight tonnage, though in this period ship size tended to be standardized. The exception is tankers controlled by the U.S. government included in the 1946 register, which at 1,600 DWT tended to be smaller than commercial tankers typically recording capacity of around 10,000 DWT. HHI for 1946 calculated treating both IOC firms and U.K. and U.S. government ownership as single units.

59. Calculated by authors from H. Clarkson and Company, *The Tanker Register* (London: H. Clarkson, 1980); H. Clarkson and Company, *The Tanker Register* (London: H. Clarkson, 1984); and

the data thus show that the commercial tanker market has also tended toward greater dispersion, and is generally lower than in the production segment of the oil supply chain. These data suggest, in turn, that the commercial tanker market is insufficiently concentrated to confer the potential for coercion to a single actor or group of actors.[60]

MIDSTREAM—MARITIME (MILITARY)

The exercise of market power in the commercial tanker market is not the only strategy available to states seeking to coerce others. Military power can plausibly be used to disrupt tanker traffic, and thus impose significant costs on an oil-importing state. The use of military power as an instrument of coercion differs from the coercive use of the commercial tanker market because it involves a blockade or other naval action against commercial shipping. The ability to impose costs through the application of military power is thus conditioned by geographic, technological, and other factors not captured by a measure of market concentration.

In this section, we examine coercive potential in the midstream segment through the exercise of military power. We calculate coercive potential in the midstream using Barry Posen's concept of U.S. "command of the commons" to approximate the extent to which military capabilities are concentrated in a single state. The commons are defined as sea (outside littoral regions), space, and air (above 15,000 feet); domination of these areas means that a state "can credibly threaten to deny their use to others; and that others would lose a military contest for the commons if they attempted to deny them."[61] We use two measures relevant to the command of the commons. The first is the concentration of global military spending by states. The second is specific to naval power and focuses on naval tonnage and number of ships.[62] Together, they offer a first approximation of the potential for coercion through military power applied to the midstream shipping of oil.

Although useful, these measures fail to capture how technology and geography affect the ability of states to impose significant costs on an adversary, even

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Clarkson Research Services Limited, *The Tanker Register 2013* (London: Clarkson Research Services Limited, 2013), p. 25, table 24.

60. For a discussion of the role of spare capacity in the tanker market, see Levi, "Enduring Vulnerabilities"; and Gholz and Press, "Enduring Resilience."

61. Barry R. Posen, "Command of the Commons: The Military Foundation of U.S. Hegemony," *International Security*, Vol. 28, No. 1 (Summer 2003), p. 8.

62. Here we follow David T. Burbach et al., "Weighing the U.S. Navy," *Defense Analysis*, Vol. 17, No. 3 (December 2001), pp. 259–266.

in the presence of overwhelming military power.[63] In the case of the oil market, for example, geographic distance and the existence of choke points in the Strait of Hormuz and elsewhere potentially reduce the advantage conferred by superior military power. We therefore analyze historical attempts to blockade oil tanker shipping that vary by technology and geography in the second part of the section. Our analysis suggests that command of the commons gives the dominant state the ability to impose significant costs on an adversary.

Regarding global defense spending, military power is clearly concentrated in the United States: data on global defense spending from the Stockholm International Peace Research Institute show that the United States was responsible for approximately 43 percent of the global total in 2010. Moreover, ten of the next fourteen largest defense budgets, representing roughly 25 percent or more of world defense spending, are controlled by allies of the United States.[64] Military power thus remains concentrated in the United States and among its allies, which combined spend more than two-thirds of the global total.

An analysis of specific capabilities in the maritime environment produces similar results. We calculate the concentration of naval capabilities in the maritime segment by adding the displacement weight of major navies excluding all surface vessels weighing less than 1,000 tons, and focusing on the navies of France, Japan, the Soviet Union/Russia, the United Kingdom, and the United States. Doing so yields a measure consistent with the results from aggregate military spending, showing that naval power has been highly concentrated since 1945.[65] The U.S. Navy, by weight, was clearly dominant in the highly

63. On the problems of estimating military power, see William C. Wohlforth, *The Elusive Balance: Power and Perceptions during the Cold War* (Ithaca, N.Y.: Cornell University Press, 1993); William C. Wohlforth, "The Perception of Power: Russia in the Pre-1914 Balance," *World Politics*, Vol. 39, No. 3 (Spring, 1987), pp. 353–381; Andrew W. Marshall, "Problems of Estimating Military Power" (Santa Monica, Calif.: RAND Corporation, 1966); and Aaron L. Friedberg, "The Assessment of Military Power: A Review Essay," *International Security*, Vol. 12, No. 3 (Winter 1987/88), pp. 190–202.

64. Data are from Stockholm International Peace Research Institute, *SIPRI Military Expenditure Database*, http://milexdata.sipri.org/. Data from *The Military Balance* produce a similar estimate. See International Institute for Strategic Studies (IISS), *The Military Balance 2012* (London: IISS, 2012), p. 31.

65. This follows the approach of Burbach et al., "Weighing the U.S. Navy," which excludes surface vessels of less than 1,000 tons because they are used for coastal defense rather than projection of power on the high seas. As the high seas are the primary arena for contesting midstream energy shipments, this methodology is appropriate for our purposes. We calculate naval HHI on a decadal basis, given that naval tonnage typically changes very slowly because of shipbuilding expenses and lengthy time lines. Two exceptions interrupted this pattern: the first occurred during World War II and led to major expansion of all fleets except for that of Japan, which was completely destroyed; and the second followed the collapse of the Soviet Union, which decimated the Soviet Navy.

concentrated naval environment of the Cold War, with the exception of the period 1976–86, when the Soviet Navy was roughly two-thirds its size. If, however, one includes the other major fleets, all of which are controlled by U.S. allies, market concentration has remained strongly favorable to the United States.

In contrast, in the pre–World War II period naval power was less concentrated.[66] Although naval power will likely always be relatively concentrated given the low number of great powers that can maintain significant high seas fleets, the coercive capacity of naval power in the midstream was much less before World War II than it was afterward. In addition, unlike the United States and the Soviet Union during the Cold War, none of the great powers before World War II had any formal alliance commitments similar to NATO or the U.S.-Japan bilateral agreement.

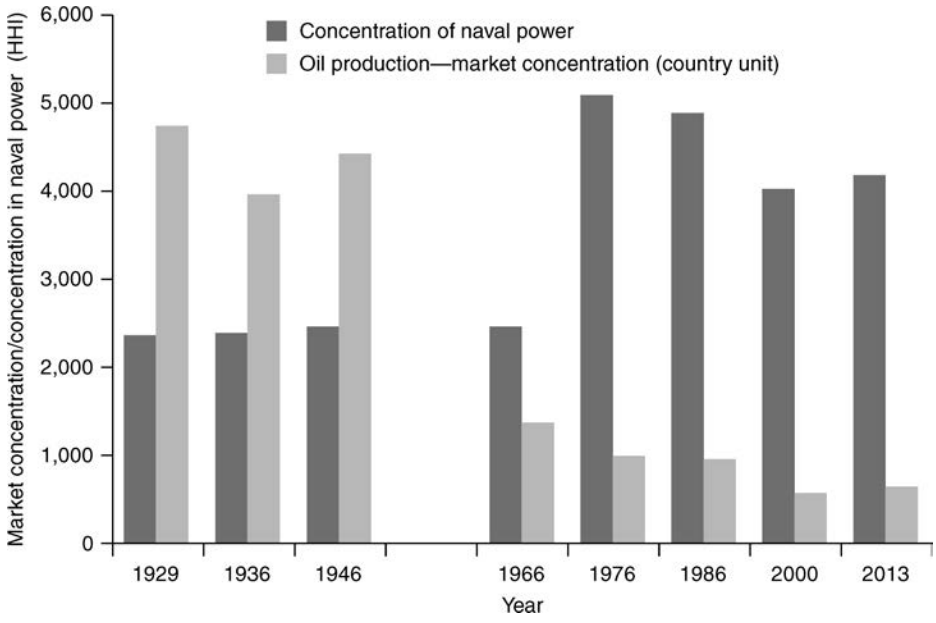
In the post–Cold War period, naval power has remained highly concentrated.[67] In 2000, the concentration was the highest it had been since 1966, which is unsurprising given the post-Soviet collapse of the Russian Navy and that China had only just begun a drive to expand its navy. By 2013 the expansion of Chinese and Indian high seas naval capability reduced the concentration of naval power from this post–Cold War peak, yet it remains significantly higher than before World War II. If one recalculates the concentration of naval power applying the measure used for other market segments, the U.S. Navy and its treaty allies as one unit are shown to be clearly dominant, exceeding the degree of concentration exhibited in the upstream segment of the oil supply chain (see figure 2).

Data also demonstrate U.S. dominance in technologies relevant to naval interdiction of oil tanker traffic. The United States has 62 out of a world total of 106 nuclear attack submarines (58.5 percent), and U.S. allies France and the

66. Data for 1936 are drawn from Burbach et al., "Weighing the U.S. Navy." We calculated 1929 HHI using data from "The New Navies," *Popular Mechanics*, Vol. 51, No. 5 (May 1929), p. 745. The major navies used in the 1929 calculation are the signatories to the Washington Naval Treaty: the United States, the United Kingdom, Japan, France, and Italy. The Soviet Union had only a few significant naval vessels prior to its naval buildup in the 1930s.

67. Data for 2000 are drawn from Burbach et al., "Weighing the U.S. Navy." We calculated 2013 HHI for the navies of the United States, the United Kingdom, Russia, China, Japan, France, and India using data from IISS, *The Military Balance 2014* (London: IISS, 2014); and *Jane's World Navies* database, http://www.ihs.com/products/janes/security/military-capabilities/world-navies.aspx. We used criteria similar to those of Burbach et al., counting all capital ships (aircraft carriers, cruisers, destroyers, submarines, and frigates) and excluding coastal patrol or coast guard vessels as well as auxiliary ships. We also excluded amphibious warfare vessels with the exception of the nine ships of the U.S. Navy's Tarawa/Wasp class, which have a flight deck and complement of fixed wing attack aircraft that make them functionally small aircraft carriers.

Figure 2. Market Concentration in Oil Production and Concentration in Naval Power



NOTE: Market concentration in oil production calculated using market shares of oil-producing states. Data drawn from *BP Statistical Review of World Energy 2014*. No data available for 1946–66; 1944 data on oil production used for 1946. See text for calculation method for concentration in naval power; data from "The New Navies," *Popular Mechanics,* Vol. 51, No. 5 (May 1929); David T. Burbach et al., "Weighing the U.S. Navy," *Defense Analysis,* Vol. 17, No. 3 (2001), pp. 259–265; and *The Military Balance 2014* (London: International Institute for Strategic Studies, 2014).

United Kingdom have another 13, giving the United States and its allies control of nearly 71 percent of these submarines globally.[68] U.S. military power in carrier battle groups is equally overwhelming: the navy operates 11 of 14 aircraft carriers worldwide (78.6 percent).[69] Differences in technology, crew proficiency, and maintenance are likely to shift the balance even more decisively in favor of the United States.[70]

68. IISS, *The Military Balance 2012*, p. 36. This counts nuclear guided missile submarines in the total for all countries.
69. Ibid., p. 35.
70. An assessment of Russian submarines notes, "[M]ore recent constraints on Russia's global naval ambitions range from the limitations of its domestic industry to a lack of experienced and well-trained crews." See *Jane's Sentinel Security Assessment—Russia and the CIS* (Englewood, Colo.: IHS, March 2012), http://www.ihs.com/products/janes/security/country-risk/index.aspx.

Military power in the midstream segment is thus concentrated in the United States and its allies, suggesting the potential for imposing significant costs on others. Historical cases also suggest that although geography and technology can provide short-term advantages, overall naval power remains more important in determining success in interdicting maritime oil transport. In World War II, both Germany and the United States targeted oil tankers. The former had only transient success given Allied naval superiority, whereas the latter almost totally severed Japanese oil imports. In the Tanker War in the Persian Gulf between Iran and Iraq during the 1980s, limited maritime and aviation assets prevented both sides from inflicting much damage despite favorable geography.

The German U-boat campaign against Allied oil tankers followed the Japanese attack on Pearl Harbor. At that time, the United States transported 95 percent of its oil from fields in Texas and Louisiana to East Coast refineries by sea. Oil and refined products also moved by tanker from Aruba, Curaçao, Trinidad, and Venezuela.[71] The first U-boat attacks took place off the coast of New York City in January 1942, sinking two tankers.[72] The campaign then shifted to the south, particularly in the geographically favorable waters around Cape Hatteras, in North Carolina, and off the coast of Florida.[73]

Naval power favored the United States in absolute terms and within the Atlantic campaign. The Germans had 20 Type IX U-boats that could reach the U.S. coast from New York to Florida in early 1942, while 8 were not combat ready.[74] In contrast, the U.S. Navy had 92 destroyers in the Atlantic and approximately 100 aircraft available for scouting or antisubmarine warfare.[75] This force was supplemented by Allied assets from the Royal Navy and Royal Canadian Navy.

The U-boats initially inflicted serious damage to the Allies' tanker fleet. By March 1942, the campaign had sunk 45 tankers and damaged another 13. British Prime Minister Winston Churchill noted that the losses meant Britain might "be compelled to halt tanker sailings."[76] In the Caribbean, tanker traffic ground to a halt as tanker crews mutinied and giant refineries ceased operations because of a lack of oil. In exchange the Germans lost only four

71. Clay Blair, *Hitler's U-Boat War: The Hunters 1939–1942* (New York: Modern Library, 2000), pp. 467–468, 503–504.
72. Ibid., pp. 460–461.
73. In these areas the continental shelf is narrow, allowing submarines to strike in coastal waters and then quickly retreat to deeper water.
74. Ibid., pp. 437–438.
75. Ibid., pp. 440, 448, 462–463.
76. Ibid., p. 521.

U-boats.[77] Tanker losses continued to mount; in the first eight months of 1942, U-boats sank 188 tankers, 143 of which were in U.S. waters.[78] The losses restricted military operations and led to rationing in the civilian economy.[79]

The effectiveness of the U-boat campaign was relatively short, however, given Allied naval dominance and improvements in Allied antisubmarine warfare.[80] By mid-1943 the German navy had been forced to withdraw its U-boats from much of the North Atlantic, and German submariners increasingly viewed their missions as suicidal.[81] The German campaign suggests that a country lacking dominance in maritime market power can inflict substantial (if temporary) damage on hydrocarbon transport through a combination of surprise, geography, and new technology. Yet in this case, overall naval power ultimately proved decisive.

The U.S. campaign against Japan, on the other hand, suggests that a dominant naval power can cripple hydrocarbon transport.[82] The weak position of the U.S. Navy following the December 1941 Japanese attack on Pearl Harbor was reversed in the Battle of Midway in June 1942 and the Battle of Guadalcanal in November 1942.[83] This resurgence enabled a campaign against Japanese oil transport that grew more effective over time, as the U.S. Navy seized bases ever closer to the Japanese home islands. These bases allowed the U.S. military to overcome the geographic disadvantage imposed by the vastness of the Pacific Ocean and allowed the use of submarines and aircraft to attack oil tankers.

The postwar Strategic Bombing Survey notes that despite synergies between elements of the campaign that were not fully exploited, "[o]il imports from the south . . . had been eliminated by April 1945. Crude oil stocks were virtually

77. Ibid., pp. 508, 520.
78. Ibid., p. 696.
79. Ibid., pp. 696–697.
80. The German navy developed more advanced U-boats in response, but the war ended before they could be deployed. See Owen R. Coté Jr., *The Third Battle: Innovation in the U.S. Navy's Silent Cold War Struggle with Soviet Submarines*, Newport Paper No. 87 (Newport, R.I.: U.S. Naval War College Press, 2000), pp. 13–18; and Howard Grier, *Hitler, Donitz, and the Baltic Sea: The Third Reich's Last Hope, 1944–1945* (Annapolis: Naval Institute Press, 2007), pp. 167–191.
81. Clay Blair, *Hitler's U-Boat War: The Hunted 1942–1945* (New York: Modern Library, 2000), pp. 338–354.
82. On the submarine campaign and its initial difficulties, see Clay Blair Jr., *Silent Victory: The U.S. Submarine War against Japan* (1975; repr., Annapolis: Naval Institute Press, 2001); and Joel Ira Holwitt, *Execute against Japan: The U.S. Decision to Conduct Unrestricted Submarine Warfare* (College Station: Texas A&M University Press, 2009).
83. For an overview, see Dan van der Vat, *The Pacific Campaign: The U.S.-Japanese Naval War 1941–1945* (New York: Simon and Schuster, 1991).

exhausted; refinery operations had to be curtailed; and stocks of aviation gasoline fell to less than 1,500,000 barrels, a point so low as to require a drastic cut in the pilot-training program and even in combat air missions."[84] As in the German case, aggregate naval power eventually proved decisive, suggesting the effectiveness of dedicated campaigns against tankers when states possess dominant naval power.

A third case of a naval campaign against oil-related transport is the Iran-Iraq Tanker War. This case suggests that campaigns against oil transport are less effective absent substantial maritime (and aviation) power, even with favorable geography. It is included here because it represents the most recent significant effort to coerce using military power in the midstream of oil transport. The lack of significant success by either Iran or Iraq underscores the central finding that coercion is dependent on the concentration of military power.

The Tanker War began in late 1983, with Iraqi air strikes using Super Etendard aircraft firing Exocet antiship missiles on tankers near the Iranian oil terminal at Kharg Island. Armed with small warheads, the missiles inflicted only limited damage.[85] Iran had greater naval assets than Iraq and blockaded Iraqi maritime oil terminals (which were geographically concentrated around Um Qasr, Iraq's only major Gulf port), yet Iraq was able to continue trading oil via overland pipelines. Iran then shifted to targeting oil tankers associated with the Gulf monarchies that were helping finance Iraq's war effort. Iranian airpower was limited, however, and the results were also unimpressive.[86]

Despite the relatively confined geography of the Gulf, which allowed for easy use of land-based aircraft by both sides and constrained tanker routes, in five weeks of attacks the two sides combined to hit only 10 tankers, sinking none. The impact on oil flows and oil market prices was minimal.[87] This pattern continued throughout the war, and by the end of 1987, both sides had combined to strike about 259 tankers, again with minimal impact on oil flows and prices.[88]

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84. Franklin D'Olier et al., *United States Strategic Bombing Survey Summary Report (Pacific War)* (Washington, D.C.: GPO, 1946), p. 15.
85. Martin S. Navias and E.R. Hooton, *Tanker Wars: The Assault on Merchant Shipping during the Iran-Iraq Conflict, 1980–1988* (London: I.B. Tauris, 1996); and Thomas Kupersmith, "The Failure of Third World Airpower: Iraq and the War with Iran," master's thesis, School of Advanced Airpower Studies, 1993.
86. Anthony H. Cordesman and Abraham R. Wagner, *The Lessons of Modern War*, Vol. 2: *The Iran-Iraq War* (Boulder, Colo.: Westview, 1990), pp. 194–196.
87. Ibid., pp. 194–195.
88. Ibid., p. 546.

The campaign did have some tactical impact. Iran was forced to adapt the way in which it exported oil, by running a tanker shuttle from Kharg Island, its main oil terminal, to terminals outside the range of Iraqi aircraft.[89] The Iranian effort compelled the Gulf monarchies to request U.S. intervention. Yet neither side lost the ability to export oil. A major limiting factor on Iran was the intervention of the U.S. Navy. In 1987 it began convoy operations to protect reflagged Kuwaiti tankers. U.S. air and special operations also engaged Iranian mine-laying boats. Following a missile strike on a reflagged tanker in late 1987, the U.S. Navy attacked Iranian oil platforms. After one of its ships struck an Iranian mine in early 1988, it launched further retaliatory attacks, leading to a decrease in Iranian tanker attacks.[90]

The foregoing discussion suggests that weak naval powers, such as Iran and Iraq, have limited ability to impede tankers even with favorable geography (though Iran did successfully blockade Iraq's geographically concentrated oil terminals).

Iran has sought to improve its capability to exploit the geography of the Gulf—particularly the critical Strait of Hormuz, which controls passage in and out of the Gulf—in an effort to interdict maritime transport in crisis. Yet many analysts argue that, despite the advantage of geography and potentially surprise, Iran's ability to close the strait is limited. As with the German U-boat campaign, U.S. and allied naval superiority would ultimately be decisive.[91]

In contrast to Iran's limited maritime interdiction capability, U.S. and allied naval superiority would likely be successful in interdicting maritime transport on the high seas. The U.S. military has a variety of options to interdict transport depending on the geographic context. The United States could attempt to implement a distant blockade using a choke point such as the Strait of Hormuz or the Strait of Malacca; conduct a near blockade of major ports with oil offloading infrastructure; attack refineries and other infrastructure for converting crude oil into oil products; or some combination of these.

Discussions of U.S. engagements against oil transport at present focus on a distant blockade of oil transport to China, as a potential adversary of the United States. In these scenarios, the U.S. Navy would interdict and inspect

89. Ibid., p. 543.
90. For an overview of the U.S. intervention, see Harold Lee Wise, *Inside the Danger Zone: The U.S. Military in the Persian Gulf 1987–1988* (Annapolis: Naval Institute Press, 2007).
91. Talmadge, "Closing Time"; and Michael A. McDevitt and Michael P. Connell, "Iran and the Strait of Hormuz," in McDevitt et al., eds., *The Long Littoral Project: Arabian Sea* (Alexandria, Va.: Center for Naval Analyses, 2012).

tankers carrying oil to China in and around the Strait of Malacca and Lombok. Such a blockade would be outside the reach of most Chinese maritime assets, but could require the U.S. Navy to seize numerous tankers with an array of different owners. An assessment by Gabriel Collins and William Murray suggests that a blockade of this type would be difficult to implement, whereas Douglas Peifer maintains that any difficulties could be relatively easy to overcome through doctrinal adaption.[92]

There are, however, other options. For example, the United States could undertake a close blockade or quarantine against Chinese ports. Collins and Murray argue that a close blockade would need to focus on "China's three major oil-handling port concentrations, Guangzhou/Hong Kong, Shanghai/Ningbo, and Tianjin/Dalian," describing such a blockade as difficult.[93] Yet if the confrontation with China were serious, the U.S. military could opt to sink rather than seize ships that violate a declared naval quarantine zone around those regions.

Sinking Very Large Crude Carriers is not easy, as the Iran-Iraq Tanker War indicates. Yet even with the limited antiship capabilities of the Tanker War, an Exocet missile strike on a 357,000-ton Saudi tanker ruined the vessel.[94] Further, the U.S. Navy has substantially larger and more powerful weapons than the Exocet, such as the Mark 48 heavy torpedo and 2,000-pound precision-guided bombs.[95] There is thus little reason to believe that the U.S. military would have difficulty sinking or otherwise crippling Very Large Crude Carriers.

A blockade that was enforced by the sinking of ships would undoubtedly have serious escalatory potential both with China and with third-party tanker owners. Yet many analysts believe that China would be willing to run such a risk by blockading Taiwan.[96] It therefore seems plausible that the United States

92. Gabriel B. Collins and William S. Murray, "No Oil for the Lamps of China?" *Naval War College Review*, Vol. 61, No. 2 (Spring 2008), pp. 79–95; and Douglas C. Peifer, "Power Projection versus Distant Blockade: China, the German Analogy, and the New AirSea Operational Concept," *Orbis*, Vol. 55, No. 1 (Winter 2011), pp. 114–131. For another assessment, see Sean Mirski, "Stranglehold: The Context, Conduct, and Consequences of an American Naval Blockade of China," *Journal of Strategic Studies*, Vol. 36, No. 3 (June 2013), pp. 385–421; and Evan Braden Montgomery, "Reconsidering a Naval Blockade of China: A Response to Mirski," *Journal of Strategic Studies*, Vol. 36, No. 4 (August 2013), pp. 615–623.

93. Collins and Murray, "No Oil for the Lamps of China?" p. 89.

94. Cordesman and Wagner, *The Lessons of Modern War*, p. 535.

95. The Exocet has a 165-kilogram explosive warhead, whereas a 2000-pound bomb has a 429 kilogram warhead. The Mark 48 torpedo has a 295-kilogram warhead. Because it is intended to detonate below a ship's waterline (ideally beneath the keel), a torpedo warhead typically inflicts much more damage than equivalent bomb or missile warheads.

96. Lyle Goldstein and William Murray, "Undersea Dragons: China's Maturing Submarine Force,"

would also be willing to run this risk, particularly if the blockades were symmetric (i.e., the U.S. blockade was in response to a Chinese blockade). Moreover, this naval quarantine could exploit U.S. advantages in submarine technology to avoid Chinese investments in so-called antiaccess/area denial systems that operate against air and surface assets.[97] U.S. air assets could then operate outside the range of these systems in support of the blockade.[98]

midstream—oil importer responses

The analysis above shows that market concentration in the commercial tanker market is low and has fallen over time. The potential of the United States to impose significant costs on an oil-importing state through the interdiction of tanker traffic, on the other hand, has remained high since the end of the Cold War. Our empirical expectation is that oil-importing states should implement policies to manage the potential for coercion. In the case of the commercial oil tanker market, there appears, as expected, to be little intervention designed to reduce market concentration. In 1996, states maintained direct ownership of 66 of the world's 447 (14.8 percent) tankers. This represents an increase from 22 tankers out of a total of 636 in 1976 (3.6 percent), but is still small in absolute terms. An exception is China, which supports the development of a domestic tanker industry. Analysts note, however, that state intervention may represent "commercial interests pursuing profits under the banner of enhancing national

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International Security, Vol. 28, No. 4 (Spring 2004), pp. 161–196; and Michael A. Glosny, "Strangulation from the Sea? A PRC Submarine Blockade of Taiwan," *International Security*, Vol. 28, No. 4 (Spring 2004), pp. 125–160.

97. Ronald O'Rourke, "China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress" (Washington, D.C.: Congressional Research Service, 2012). These technologies are intended to push outward the contested littoral/low-altitude zone, thus shrinking the size of the "commons." See also Evan Braden Montgomery, "Contested Primacy in the Western Pacific: China's Rise and the Future of U.S. Power Projection," *International Security*, Vol. 38, No. 4 (Spring 2014), pp. 115–149; and Aaron L. Friedberg, *Beyond Air-Sea Battle: The Debate over US Military Strategy in Asia* (London: IISS, 2014).

98. See Owen R. Coté Jr., "Assessing the Undersea Balance between the U.S. and China," working paper (Cambridge, Mass.: Security Studies Program, Massachusetts Institute of Technology, February 2011); and Jeff Hagen, "Potential Effects of Chinese Aerospace Capabilities on U.S. Air Force Operations," testimony presented before the U.S.-China Economic and Security Review Commission, May 20, 2010 (Santa Monica, Calif.: RAND Corporation, 2010). Chinese long-range fighters could engage aircraft more than 150 miles from the Chinese coast, but these aircraft would need additional cuing by Chinese Airborne Warning and Control (AWAC) aircraft. AWACs are potentially vulnerable and therefore unlikely to operate far off the Chinese coast; in addition, they have a likely radar range against fighter aircraft of 250 miles or less. Thus U.S. aircraft flying more than 250 miles offshore would likely be relatively safe from Chinese attack. See Martin Streetly, "Electronic Eyes on Wings and Rotors: Sensors Improved for Enhanced Airborne Early Warning," *Jane's International Defence Review*, November 1, 2005.

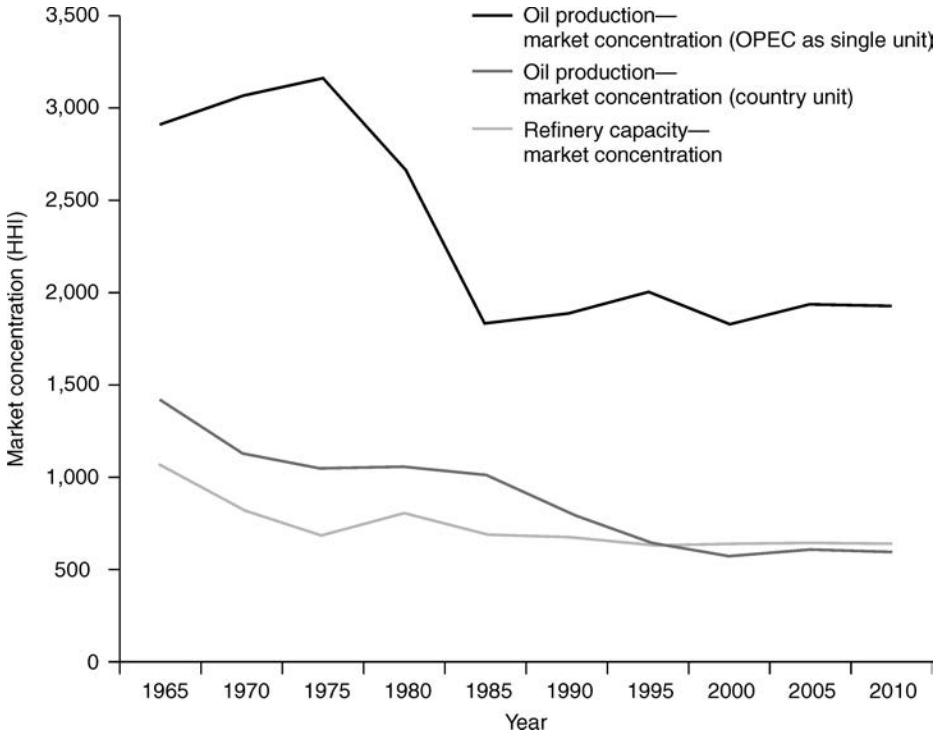
energy security," rather than a state-led response to the risks of coercion. The market share of Chinese firms in the global tanker market also remains small in absolute terms.[99]

The dominance of U.S. air and naval power, on the other hand, implies an increased risk of coercion for states that depend on maritime transport of oil and that are potential adversaries of the United States. In the case of China, in particular, analysts propose the naval dominance of the United States as a cause of the expansion of its antiaccess/area denial capabilities, which threaten to produce a security dilemma in which both sides take "defensive" measures that provoke a response from the other.[100] This spiral is particularly dangerous, because some of the technologies that China is developing create incentives for both sides to strike first. For example, antiship ballistic missiles require over-the-horizon sensors to target U.S. and allied ships. In the near term, the Chinese appear to be planning to rely on over-the-horizon backscatter radars that are large, fixed targets and are few in number, making them an easy and valuable target for a U.S. strike.[101] As a result, Chinese forces would face pressure to use them early in a crisis, in turn giving U.S. forces an incentive to strike these targets early.[102] U.S. and Chinese capabilities to launch cyberattacks on military command and control may create additional first-strike incentives.[103] Yet, even if the Chinese are successful in developing effective and survivable antiaccess/area denial capabilities, the United States and its allies will still dominate the high seas outside the range of these systems.

The concentration of naval power thus creates significant potential for coercion. Further, it is more vulnerable to targeting than it is in the upstream segment. Absent a major decline in U.S. and allied naval capabilities or a vastly larger Chinese, Indian, and/or Russian naval expansion (which would

99. Andrew Erickson and Gabe Collins, "Beijing's Energy Security Strategy: The Significance of a Chinese State-Owned Tanker Fleet," *Orbis*, Vol. 51, No. 4 (September 2007), p. 673.
100. On oil and the security dilemma, see Glaser, "How Oil Influences U.S. National Security."
101. Jonathan Solomon, "Defending the Fleet from China's Anti-Ship Ballistic Missile: Naval Deception's Roles in Sea-Based Missile Defense," M.A. thesis, Georgetown University, 2011. Additional possible vulnerable targets include Chinese satellites, data fusion centers, and other components of command and control. See Coté, "Assessing the Undersea Balance between the U.S. and China," pp. 16–17.
102. Glenn Kent and David Thaler, "First-Strike Stability: A Methodology for Evaluating Strategic Forces" (Santa Monica, Calif.: RAND Corporation, 1989).
103. Patrick Morgan, "Applicability of Traditional Deterrence Concepts and Theory to the Cyber Realm," in *Proceedings of a Workshop on Deterring Cyber Attacks* (Washington, D.C.: National Academies Press, 2010), pp. 55–76; and David C. Gompert and Martin Libicki, "Cyber Warfare and Sino-American Crisis Instability," *Survival*, Vol. 56, No. 4 (August/September 2014), pp. 7–22.

Figure 3. Market Concentration in Refinery Capacity and Oil Production



NOTE: Market concentration in refinery capacity for major markets is used given data availability; Market concentration in oil production calculated using market shares of oil producing states; all data from *BP Statistical Review of World Energy 2014.*

take years if not decades), this concentration will not decrease significantly, implying that the long-run risk for energy importers is U.S. maritime midstream dominance.

DOWNSTREAM—REFINING AND DISTRIBUTION

The downstream refining of crude oil and distribution of refined products to consumers is the final stage of the oil supply chain. Here data show that market concentration has fallen over time when measured on a country basis, and that it is lower than in the upstream segment (see figure 3). This stands in contrast to the pre–World War II period, when refining capacity was often colocated with crude production. In 1918, for example, U.S. firms exported more

than 62 million barrels of refined products annually, compared to 5.9 million barrels of crude oil. Refined products constituted a mean of 77 percent of total annual oil and oil product exports from the United States from 1918 to 1944.[104]

The economics of shipping refined products changed as the number of refined products increased.[105] States also actively sought to promote domestic refining as a response to the market power of U.S.-based firms.[106] Market concentration fell globally as a result. This remains the case despite the scrapping of refining capacity in the major oil-consuming regions in the 1980s and 1990s and the rise of export refineries in oil-producing states. Global refining capacity increased from 34.5 mbd in 1965 to 94.9 mbd in 2013, but total refining capacity in North America and Europe fell from 72.7 percent of aggregate global capacity in 1965 to 47.7 percent in 2013. In contrast, total refining capacity in the Asia Pacific rose from 10.4 percent to 33 percent over the same period.[107]

The national or regional focus of many refineries means that trade in refined oil products among the major consumer states is limited, with imports providing only a small fraction of total demand for products such as gasoline.[108] This lack of trade greatly decreases the potential for coercion. The volume of trade in oil products has started to increase in recent years, however. Global product exports grew from 10.8 mbd in 1986 to 24.7 mbd in 2010, the latest year for which comprehensive data are available. In Europe, member states imported 877,000 barrels of products in net terms in 1984, falling to 129,000 in 2004 but rising to 909,000 barrels in 2010. Trade patterns show considerable variation across product type and country. The United States shifted from being a net importer to a net exporter of 161,000 barrels of gasoline, for example, and a net exporter of 427,000 barrels of distillate fuels over the same period. In the case of gasoline, European Union member states exported a net of 102,000 barrels per day in 1984, rising to 946,000 barrels in 2010. In contrast, distillate fuels in-

104. Authors' calculations use data on mean annual barrels exported drawn from DeGolyer and MacNaughton, *Twentieth Century Petroleum Statistics Historical Data*, p. 63.
105. J.D. Butler, "The Influence of Economic Factors on the Location of Oil Refineries," *Journal of Industrial Economics*, Vol. 1, No. 3 (July 1953), pp. 191–192.
106. For an example, see Peter P. Waller and Harry S. Swain, "Changing Patterns of Oil Transportation and Refining in West Germany," *Economic Geography*, Vol. 43, No. 2 (April 1967), pp. 143–156.
107. Calculations by authors from BP, *BP Statistical Review of World Energy, 2010.*
108. A 2000 study by the U.S. National Petroleum Council found that "net foreign imports of gasoline, diesel, jet fuel, and blending components have provided a supply of between 2 and 7% of the U.S. demand since 1970." See National Petroleum Council, *U.S. Petroleum Refining: Assuring the Adequacy and Affordability of Cleaner Fuels* (Washington, D.C.: National Petroleum Council, June 2000), p. 41.

creased from net imports of 353,000 barrels to 563,000 barrels between 1984 and 2010. Japanese net imports were stagnant, increasing from 888,000 to 960,000 barrels per day between 1984 and 2010.

One reason for these changes is the rising number of export refineries in the Middle East, which led to an increase in exports from 1.8 mbd in 1986 to 3.5 mbd in 2010. Saudi Arabia increased its exports from 611,000 barrels per day to 1.5 mbd over the same period.[109] Cross-regional differences in the structure of demand for product types offer another explanation. European refiners, for example, tend to produce more gasoline than is used domestically, while needing to import diesel to meet domestic demand in the transport sector.[110] The increase in oil production in the United States since 2010 is concentrated in light, sweet oil, which not all refineries are optimized to process.

These changes in trade patterns are not captured by measuring market concentration on a national basis. Crude oil also varies by density, sulfur content, and other factors, and refineries cannot seamlessly change the types of crude oil they process. An important challenge facing refiners is managing the increasing supply in heavy, sour crudes when the products demanded by consumers are increasingly gasoline and other lighter products. This supply-demand mismatch requires investment in technologies designed to break up the heavier crude oil molecules for processing. Regardless, these factors do not alter the conclusion that there is little potential to coerce in the downstream segment.[111] Refineries can manage differences in crude qualities. Refiners compensated for the loss of almost 3 mbd of heavy, sour Venezuelan crude exports in 2002 through a combination of large inventories, as well as blending imports of oils of different qualities from Mexico, the Middle East, West Africa, and the North Sea.[112] A survey of U.S. refineries similarly found that a combi-

109. Figures calculated by authors using annual data on petroleum product imports and exports compiled by the EIA, "Petroleum and Other Liquids."
110. Purvin and Gertz Inc., *Study on Oil Refining and Oil Markets Prepared for: European Commission* (Houston: Purvin and Gertz Inc., January 2008), pp. 88–89.
111. Analysts have noted the potential for the emergence of supply risks in the refining segment, although they have not focused on the potential for coercion. In the case of the United States, for example, D.J. Peterson and Sergej Mahnovski have asked whether "foreign refiners [will] have the processing capacity and capabilities to service the U.S. market with either intermediate or finished products in a reliable and sustained manner." See Peterson and Mahnovski, *New Forces at Work in Refining: Industry Views of Critical Business and Operations Trends* (Santa Monica, Calif.: RAND Corporation, 2003), p. 90.
112. Joanne Shore and John Hackworth, "Impacts of the Venezuelan Crude Oil Production Loss" (Washington, D.C.: EIA, n.d.), http://www.eia.gov/pub/oil_gas/petroleum/feature_articles/2003/venezuelan/vzimpacts.htm.

nation of inventories and net imports moderates the effects of product curtailments resulting from refinery outages.[113]

DOWNSTREAM—OIL IMPORTER RESPONSES

The low potential for coercion in the refining segment of the oil supply chain leads to the expectation that states have reduced the level of intervention in refining markets designed to manage the risks of coercion. This is largely reflected in the data. In the period when IOCs and U.S.-based refineries dominated international trade in oil products, European states and Japan used preferential tariffs and other means to promote the localization of refining, thus diversifying refinery capacity.[114] In the 1980s and 1990s, in contrast, states reduced efforts to diversify refining capacity.

The European Commission monitored developments in Europe's refining sector in the 1980s and 1990s, as member states reduced capacity while export-oriented refineries in Kuwait, Libya, and Saudi Arabia increased capacity. Rather than limiting imports of refined products, however, the Commission recommended loosening controls over oil product trade and investment. It also did not withdraw unilateral concessions to oil product exporters conferred under the Generalized System of Preferences, thus allowing them to continue to increase market share in Europe.[115] A 1992 review of European oil policy noted the "strategic importance of a competitive refining industry to the stability of the product market and Community supply security," thus recognizing the importance of the refining segment to energy security. The review concluded, however, that the rise of export refineries did not represent an important risk.[116] Similarly, the 2010 European Commission report on the

113. EIA, "Refinery Outages: Description and Potential Impact on Petroleum Product Prices" (Washington, D.C.: EIA, March 2007), p. 30.
114. Butler, "The Influence of Economic Factors on the Location of Oil Refineries," pp. 187–201.
115. Commission of the European Communities, "The Situation in the Oil-Refining Industry and the Impact of Petroleum Product Imports from Third Countries," COM (85) 32 final, March 1, 1985, Archive of European Integration, University of Pittsburgh, Pittsburgh, Pennsylvania, pp. 15–16, http://aei.pitt.edu/3660/. These findings were reconfirmed in 1988. See Commission of the European Communities, "The Oil Market and the Refining Industry in the Community: Recent Developments and the Prospects until 1995," COM (88) 491 final, September 23, 1988, Archive of European Integration, University of Pittsburgh, Pittsburgh, Pennsylvania, http://aei.pitt.edu/3818/.
116. Commission of the European Communities, "Report on the Situation of Oil Supply, Refining, and Markets in the European Community," COM (96) 143 final, April 3, 1996, Archive of European Integration, University of Pittsburgh, Pittsburgh, Pennsylvania, http://aei.pitt.edu/6253/; and Commission of the European Communities, "Communication from the Commission to the Council: The Oil Market and the Refining Industry in the Community—Recent Developments and

development of energy infrastructure observed that "security of supply depends on the integrity and flexibility of the entire supply chain, from the crude oil supplied to refineries to the final product distributed to consumers." It concluded, however, that the market would deliver the required investments to ensure security of supply.[117]

Japan, another major oil importer, has experienced similar outcomes. Japanese responses to IOC dominance included state-sponsored cartelization and regulations favoring the construction of refineries domestically. In the 1980s and 1990s, however, the government eliminated barriers to oil product imports, ultimately abolishing the law used to limit imports in 2002. The 2013 White Paper on Energy did not record concern regarding changes in the distribution of refining that might require renewed state intervention to manage problems of market concentration.[118]

Finally, in the United States refining capacity fell in the 1980s in response to weak demand. Refining industry supporters called for a tariff on imports of oil products but were unable to mobilize Congress to take action. More recently, U.S. Energy Information Agency assessments identify little risk associated with refinery closures.[119]

Conclusion

What does a supply-chain analysis of the potential for coercion in the international oil market reveal? In this article, we have argued that the fragmentation of the international oil market requires that the potential for coercion be under-

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Prospects," COM (92) 152 final, April 14, 1992, Archive of European Integration, University of Pittsburgh, Pittsburgh, Pennsylvania, p. vii, http://aei.pitt.edu/4835/. The Commission also noted that member states provided 86 percent of total demand and that imports were "widely diversified." See Commission of the European Communities, "Report on the Situation of Oil Supply, Refining, and Markets in the European Community," p. 20, table B-2.

117. European Commission, "Energy Infrastructure Priorities for 2020 and Beyond—A Blueprint for an Integrated European Energy Network," COM (2010) 677 final (Brussels: European Commission, 2010), pp. 7–8. See also European Commission, "On Refining and the Supply of Petroleum Products in the EU," SEC (2010) 1398 final (Brussels: European Commission, 2010).

118. Japanese Ministry of Economy, Trade, and Industry, "Energy White Paper 2013" (Tokyo: Ministry of Economy, Trade, and Industry, 2013).

119. Brandon Wales, testimony before the Subcommittee on Counterterrorism and Intelligence Committee on Homeland Security, U.S. House of Representatives, 112th Cong., 2nd sess., March 19, 2012 (Washington, D.C.: Congressional Record, 2012). See also Charles Drevna, "Written Statement of American Fuel and Petrochemical Manufacturers," submitted to the Subcommittee on Counterterrorism and Intelligence, Committee on Homeland Security, U.S. House of Representatives, 112th Cong., 2nd sess., March 19, 2012 (Washington, D.C.: Congressional Record, 2012).

stood at each stage of the supply chain. We adopted a narrow definition of the potential for coercion, focusing on whether an actor, or group of actors, can impose significant costs on others through a sustained reduction in the supply of oil. Theoretically, this approach is consistent with the approaches of other studies of the relationship between oil and coercion, even as policymakers and analysts have expanded the definition of energy security over time to include concerns such as the economic impact of price shocks. Empirically, it is consistent with studies suggesting that price shocks alone have largely failed to coerce other states.

We have offered a strategy for conceptualizing and measuring the potential for coercion across market segments and have provided evidence that the degree of market concentration varies by market segment and across time. In particular, we found that the United States dominates a key segment of the oil market: maritime transport. In this sense, the United States remains a dominant presence in the international oil market, although this dominance has shifted from production—where it was prior to World War II—to the midstream-maritime environment. As a result, the United States has substantial coercive capability against both major oil importers and major oil exporters that rely on maritime transport.

There are a number of features of the international oil market not identified in our analysis that warrant further attention. Each stage of the oil supply chain incorporates characteristics not captured by a simple measure of market concentration. Although we do not believe that these change the basic conclusion of our analysis, they remain important components in analyzing the relationship between oil and coercion. Geographic constraints such as maritime choke points including the Strait of Hormuz or the Strait of Malacca could conceivably challenge the superiority of the U.S. military. The ability of states to process different qualities of crude oil also varies depending on the sophistication of domestic refineries, and the inability to process a wide variety of crudes across refinery configurations could potentially undermine the assumption of fungibility that underpins analyses of the potential for coercion in oil.

A second question not examined here is whether states are likely to be willing to bear the high costs associated with efforts to use the oil weapon. States are likely to calculate the costs they will incur in attempting coercion, in addition to the costs they impose on others. The structural shift in energy demand that occurred in the 1980s in the advanced industrialized states, for example, in addition to an economic slowdown, made it clear that the attempt at coercion by the Organization of Arab Petroleum Exporting Countries also imposed

significant costs on the group. Here the transformation of the structure of the international oil market is likely to have one additional effect: increasing the costs to the United States of using the oil weapon. Despite its coercive potential, the United States is likely to incur high costs from the use of the oil weapon not only because it has high escalatory potential, but also because the adoption of index pricing has increased the sensitivity of oil prices to geopolitical risk, relative to the period when prices were set by the IOCs through internal transfer pricing.[120] The U.S. threat of coercion in the maritime segment may thus impose economic costs on the United States, just as the imposition of an embargo in the 1970s harmed oil producers by causing a structural shift in demand even as they sought to impose costs on major oil-importing states.

Three policy implications follow from this analysis. First, the analysis confounds the conventional wisdom that the most important risk of coercion lies with oil producers and that oil-importing states are in a weak position. Despite the economic and commercial implications associated with the market concentration in the upstream segment that contribute to its politicization, data show that the potential for coercion has fallen over time. Conversely, the United States retains the ability to impose significant costs on others through its dominant naval power, even as it is likely to incur some costs from coercing others because of the sensitivity of oil prices to geopolitical risks.

Second, the dominance of the United States and its allies in the maritime segment of the oil supply chain makes it the most important long-term security problem in the international oil market. The industrializing countries of the Asia Pacific and Middle East are projected to account for the bulk of marginal demand growth in the coming decades. China, in particular, matters immensely. According to the International Energy Agency, total primary energy demand from China is calculated to grow by 2.1 percent annually from 2009 to 2035, even if a more aggressive set of policies curb the demand for fossil fuels. Under this scenario, Chinese imports of oil will also grow from 4.3 million barrels a day in 2009 to 12.8 million barrels a day in 2035, and China's share of imports relative to domestic demand will rise from 53 percent to 84 percent.[121]

120. On oil price volatility, see Philip K. Verleger Jr., *Adjusting to Volatile Energy Prices* (Washington, D.C.: Peterson Institute, 1994). See also André Plourde and G.C. Watkins, "Crude Oil Prices between 1985 and 1994: How Volatile in Relation to Other Commodities?" *Resource and Energy Economics*, Vol. 20, No. 3 (September 1998), pp. 245–262. Producers have also borne costs when attempting to use the oil weapon. A structural shift in demand through the development of substitutes outside the transport sector was one effect of the oil shocks of the 1970s, for example. Additionally, sustained periods of higher prices can stimulate new production, which serves to reduce market concentration.

121. IEA, *World Energy Outlook 2010* (Paris: OECD/IEA, 2010), pp. 98–99.

These implications challenge the conventional wisdom that Chinese oil company efforts to develop overseas supplies of oil and other raw materials is a sign of Chinese ascendance and U.S./Western decline.[122] Yet Chinese efforts to expand the global supply of oil only further reduce the coercive potential of the upstream segment. At the same time, China remains vulnerable to coercion in the midstream from U.S. naval supremacy. Although there may be other reasons for concern about Chinese activities in developing nations from an oil market perspective, these efforts only strengthen the U.S. coercive position while further reducing the power of OPEC and other producers.

The final policy implication concerns the use of economic instruments to achieve political goals. The data suggest that analyses of the potential to impose costs in markets other than oil would benefit from a similar disaggregation of supply chains. Existing accounts of the ability to impose costs tend to use individual goods as the unit of analysis.[123] Studies of the effectiveness of economic sanctions also tend to use aggregate measures such as bilateral trade as a ratio of total trade, or the anticipated economic costs associated with the imposition of sanctions. Yet the supply chain for many goods is organized across a series of discrete stages, from production, to transportation, to distribution. Additionally, the recent focus on financial sanctions suggests that analysis of markets associated with the settlement of trade is fruitful. As in the case of oil, the ability to impose costs can differ across market segments, and the relevant actor capable of imposing costs can also differ across the stage of the supply chain. Disaggregating supply chains can thus help illuminate the potential for coercion through economic instruments.

122. See, for example, Jeremy Warner, "How the West Is Losing Africa—and Latin America," *Telegraph* (U.K.), April 26, 2011.
123. See, for example, Robert L. Paarlberg, "Food, Oil, and Coercive Resource Power," *International Security*, Vol. 3, No. 2 (Fall 1978), pp. 3–19; and Mark R. Finlay, *Growing American Rubber: Strategic Plants and the Politics of National Security* (Piskataway, N.J.: Rutgers University Press, 2009).