Introduction: Is the Genie Back in the Bottle?

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We chose a title that remarks one of Professor Adelman's favorite analogies and also serves as a sign of the times. He first used the expression "the genie is out of the bottle" in 1971 in a piece for the *New York Times* (Smith, 1971)—a comment on OPEC's recent success at using threats to raise the price of oil during the so-called Tehran-Tripoli agreements of 1971. He explained the analogy in simple terms: "the producing countries have been extremely successful in using the weapon of a threatened concerted stoppage, and they cannot be expected to put it away (Adelman, 1972). Nor did they put it away. U.S. oil production had peaked in 1970 and markets were tightening. Already in February of 1971, Algeria had successfully nationalized 51% of French oil concessions. In December of 1971, Libya nationalized British Petroleum concessions. In 1972, Iraq nationalized the Iraq Petroleum Company. In 1973, Kuwait, Qatar, Abu Dhabi, Nigeria, and Saudi Arabia began nationalization, the Shah of Iran did not renew the 1954 operating agreement between a consortium of oil companies and Iran, while Libya and Iraq continued to nationalize. Venezuela nationalized in 1976 (Dahl, 2015).

Adelman used a variant of his genie expression again as the title of his book, *The Genie Out of the Bottle: World Oil Since 1970,* published in 1995. But the Genie was not always so beneficent and his book chronicles the tensions between market/monopoly (OPEC) and depletion/technical innovation over more than two decades. Again today we see that technology is trumping depletion with increasing U.S. production using new shale technology. The Genie may now be back in the bottle, but rest assured that it will always be waiting to get out. We might also think of Professor Adelman, who spouted wisdom rather than wishes, as the Genie.

Professor Adelman (Morry to his friends) touched the lives and hearts of many in his 96 years. Each of the editors of this volume volunteered for this project because of their long standing appreciation of Morry and his work, and each of us is able to offer a few personal reflections:

Carol Dahl recalls her first awareness of Professor Adelman's work in 1973. Gasoline lines were long, tempers were short. While looking for a thesis topic at the University of Minnesota, she read his 1972 book, *The World Petroleum Market*. After the seemingly endless and complicated mathematical models found in the literature, his attention to history, institution, and data were a return to the real world. It began a love affair with petroleum markets that lasts to this day. Carol has read and cited many of Professor Adelman's works over the years, applied his methodology to costing oil and gas reserves and had the opportunity to get to know him better during a semester sabbatical stay at the MIT Energy Lab in the fall of 1989.

Mike Lynch first met Morry as a researcher at the MIT Energy Laboratory in the late 1970s, after having relied on the concepts in *The World Petroleum Market* in his computer modeling work. Mike continued a long association, assisting Morry with his research and writing for three

decades. Professor Adelman taught Mike (and so many others) the value of careful scholarship, as well as a degree of irreverence.

Jim Smith first encountered the Genie in 1974 when he enrolled in Professor Adelman's graduate course on petroleum economics (Econ 14.23). After the first class meeting, Jim took a copy of *The World Petroleum Market* with him on the bus to browse during his 30-minute ride home. Some 45 minutes into the ride, only after disengaging from Professor Adelman's discussion of the concept and measurement of "reserves," did Jim realize that he had missed his stop—by five miles.

We continue our tribute to him in this introductory article in 3 sections. I. Adelman, the Man; II. Adelman, the Energy Scholar and his Work; and III. Adelman and the Articles in this Issue.

I. ADELMAN THE MAN (A SHORT BIO)

Professor Adelman, the man, had a pint-sized frame but with intellect and wit that came in gallons (As a courtesy to our more metrically sophisticated readers, that would be about 0.253 and 3.785 liters, respectively). He was born in 1917 to David and Lena (Alpert) Adelman in New York City, where he grew up. He had one sister Sara Adelman (Lewis). His wife was the late Millicent (Linsen) Adelman, he had one daughter (Barbara Adelman) and one son (the late Larry Adelman) (Levine Chapel, 2014; Geni 2015).

According to a longtime friend, (Kindleberger, 1987) Adelman got a bachelor's degree from City College of NY (1938) and got a job as a high school social science teacher. After Pearl Harbor, he took a job in Washington D.C. as an economist on the War Production Board for a short time before entering the Navy and being shipped off to the South Pacific. While serving on a landing ship, he voraciously read and absorbed a stack of classic economics texts including Marshall, Schumpeter, and Keynes, and became hooked on economics and market principles for life. He returned to attend Harvard on the GI bill, completing his Ph.D. in Economics in 1948. He split the prestigious Wells Prize for the best thesis submitted to the Department of Economics in 1949–50. That award (almost $5,000 in today's prices) was for his dissertation "The Dominant Firm with Special Reference to the A&P Tea Company." The prize landed his work in the prestigious Harvard Economic Studies Series and displayed the beginnings of his lifelong interest in industrial organization, government regulation, antitrust, and market structure (Harvard Crimson, 1950).

Professor Adelman joined the faculty of the expanding economics department at MIT. For the next decade he pursued his interest in industrial structure and concentration. With an iconoclastic bent he often went counter to popular wisdom of the time. He argued that price discrimination could intensify rather that reduce competition. He considered the effect and measurement of vertical integration and industrial concentration along with the role of antitrust legislation. He found that industrial concentration rose little over the 1930s–1950s (Adelman 1949, 1951, 1955; de Jong and Shepherd, 2007). Adelman (1959) defended A&P against antitrust claims and argued that their lower prices rose from economies of scale and efficiency that intensified rather than reduced competition (MIT News, 2014).

To our good fortune, in the next decade, he turned his analytical and inquring mind to natural gas and petroleum, which became his focus and the topic of his most extensive research for the remainder of his professional life. But more on that in the next section.

He remained on the faculty of MIT from 1948–1987, attaining the rank of full professor in 1969 (Johnson, 1999). He taught Industrial Organization and Government Regulation among other courses. Over the years he was advisor to 35 students at MIT and a mentor to many others

Duarte (2013). His Ph.D. advisees, many of whom also became prominent in the field of energy economics, include Richard L. Gordon, C. C. (Ching) Chen, Martin B. Zimmerman, Paul G. Bradley, Leslie Cookenboo, Zenon Zannetos, Arthur Wright, Jim Hanson, Leonard Waverman, and Paul Leo Eckbo.

The warm relationship he had with his students is confirmed by many quotes from them on and offline. We see mention of a kind and nurturing mentor, warm heart, broad smile, an open door, generosity with his time and support. Indeed former students and colleagues put together a Festschrift to honor his retirement (Gordon et al. 1987).

Professor Adelman was passionate about educating others about the functioning of international energy markets and was a founding member of the International Association for Energy Economics (IAEE), becoming its third President in 1980–81 and remaining a member for the rest of his life. He presented papers at more than a dozen of their conferences, most often at the annual international conference. Professor Adelman's last presentation (Adelman and Watkins. 2003b) was in Prague, when he was 86. He received the IAEE "Outstanding Contributions to the Profession Award" in 1982 (IAEE, 2015). The American Institute of Mining (AIME) had already bestowed upon him in 1979 its prestigious Mineral Economics award (Prabook, 2015).

Professor Adelman has also been honored by having things named after him. For example, The Morris A. Adelman Professorship of Management was implemented at MIT. The United States Association for Energy Economics (USAEE) founded the Adelman Frankel award in 1995 to honor Morris Adelman and Paul Frankel. In addition, Adelman was himself the recipient of that award in 1996 for his "unique and innovative contributions to the field of energy economics" (USAEE, 2015).

He was actively involved in the MIT Energy Laboratory and its Center for Energy Policy Research founded in 1974, which later broadened its scope to become the Center for Energy and Environmental Policy Research (CEEPR) in the early 1990s (CEEPR, 2015), and which subsequently became part of the MIT Energy Initiative in 2006. Professor Adelman served on the MIT Energy Lab's steering committee from 1974–1977, helped to define its agenda early on and continued his affiliation with them for decades after his retirement by contributing to their workshops and working papers, which are included in the references (CEEPR, 2014).

Professor Adelman served on various editorial boards for academic journals including *Energy Economics*, *Energy Policy*, and *Resources and Energy* as well as having been North American Editor of the *Journal of Industrial Organization*. He has also served on numerous committees including the Federal Power Commission's Executive Advisory Committee, the Gas Research Institute's Advisory Council, the American Economic Association's Advisory Committee to the Bureau of the Census, the National Academy of Science's Panel on Natural Gas Statistics, the American Petroleum Institute Coordinating Committee on Statistics and Economics, the International Oil Crises Committee, and the Gas Research Institute Advisory Council (Buddycom, 2015).

In searching for quotes about him for this piece one sees repeatedly he was a gentle and kind man, and always the gentlemen. Although he could be savage and sarcastic about foolish ideas and institutional ineptitude, many say he never made personal attacks. One also often sees him referred to as humble. When Senator Lieberman introduced him as the Dean of Petroleum Economics at testimony before a Senate committee in 1990, he deflected the compliment with a quip about deans being too old to be shot and too stupid to teach (Adelman, 1990c).

He was a master of rhetoric both in person and in print and equally at ease quoting Shakespeare, Samuel Johnston, Mr. Dooley, or Mae West. With his wit and perspicacity, he, too, has been highly quoted. The most extensive list we have found is at Bradley (2013).

The following exchange quoted by Watkins (1987, 31) is a segment from Adelman's 1969 testimony before the U.S. Senate Subcommittee on Antitrust and Monopoly, hearings on Government Intervention in the Market Mechanism: The Petroleum Industry. It displays both wit and fearlessness when trying to dispel misguided notions.

> Senator Hruska. Well, the Act of 1954 as amended by the Extension Act of 1955 was the basis for the President's mandatory oil import program.
> Dr. Adelman: Yes, sir.
> Senator Hruska. And the thrust of those acts is national security.
> Dr. Adelman. Those are the words.
> Senator Hruska. Not individual investments, not individual industries, not even the economics of the thing. The thrust was national security. Now, do you mean to tell me that all of this legislation and all of these things taken on behalf of preserving our national security is not a serious discussion and debate and effort?
> Dr. Adelman. The tone is a serious one, Senator, but the substance, I am afraid, was frivolous.
> Senator Hruska. Was what?
> Dr. Adelman. Frivolous, light-minded, not concerned with the basic facts, and I must say that reading—and I have spent many more hours than I like to recollect reading them—was like hearing the same scratchy records played over and over again.

This talent for wit and rhetoric along with strong scholarship and a careful marshalling of the facts made him a popular speaker. We have found three videos that you can sample online. He was a guest on William F. Buckley, Jr.'s *Firing Line* in 1973 along with Joch Richie from Shell Oil (Adelman 1973b). He testified at a hearing held by the Senate Governmental Affairs Committee to investigate the price of fuel after Iraq had attached Kuwait (Adelman, 1990c), and then there is the transcript (reprinted below) of the third video presentation at the Cato Institute in 1992 (Adelman, 1992a).

His wit, rhetoric, careful scholarship, intellectual integrity, and the ability to explain complex topics in lay terms also made Professor Adelman a popular expert witness in antitrust and intellectual property cases including the U.S. v. E I DuPont and Co. cellophane case filed in 1955, Honeywell v. Sperry Rand computer patent case filed 1967, and Berkey Photo v. Kodak antitrust case first filed 1979. He became the first academic affiliate at the founding of the Analysis Group in 1981 and worked with that firm on a number of cases in the 1980s, including challenged supermarket as well as chemical mergers (Analysis Group, 2014) with dates added from various internet sources).

II. ADELMAN THE ENERGY SCHOLAR AND HIS WORK

Most sources say that Professor Adelman turned to energy with a book on natural gas in 1962 but he informs us in Adelman (1997) that the affair begin rather earlier. He advised a master student's thesis on natural gas as early as 1951 (Baptista, 1951) and a Ph.D. thesis on oil pipelines a few years later (Cookenboo,1957). In 1951, he was also hired by Jersey Standard (to become Exxon and then ExxonMobil) to analyze a report by the U. S. Federal Trade Commission (FTC) (1952) on the international oil cartel (then considered to be a cartel of the large multinational oil

companies). He was also asked to do a subsequent study. Hence begin his lessons on the inside working of the oil market and its interface with domestic policy. He suggests that the investigation leading to the FTC report was prompted by government jawboning to reduce oil imports. Such imports had been increasing and threatening the U.S. price since the U.S. changed from being a net oil exporter to being a net importer in 1948.

From 1956 to 1958, he was a consultant and expert witness for a group of oil companies relating to natural gas price controls. His arguments that gas producers were competitive fell on deaf government ears but his education on the inner workings of the oil and gas industry along with government policy proceeded.

In 1962 Professor Adelman published a short book on *The Supply and Price of Natural Gas.* In it, we see the seeds of much of his later work:

A careful attention to industry detail noting the various categories of costs and what difference it makes if the gas is associated with oil or not;

A grounding in fundamental economics. For example: economies of scale, rising costs with depletion, high reserve discoveries flooding the market pushing price below total costs but falling no further than marginal operating costs, the disadvantage of high transport costs of gas (three times that of oil), excess capacity only persisting for years if prices are kept above marginal costs by monopoly constraint;

A careful attention to hard data, although he often cautions on the quality of the data (Adelman 1997; Dimsdale, 1963).

In 1962–63, Professor Adelman had a stint at *Institute Français du Pétrole* (IFP) in Paris, which turned him into a confirmed Francophile. The petroleum expertise concentrated within IFP, their excellent library, and their strong contacts with the oil and tanker industry furthered his education in petroleum. Although posted oil prices had lost any relation to real market prices from 1959 to their abandonment in the mid-1970s, three product price series (gasoline, gasoil, and heavy fuel oil) began in l960 at Rotterdam showed increasing competition in refining. These prices allowed him to use netback pricing (an innovation at the time) to compute a better approximation of oil price and demonstrate that oil prices had fallen since 1949. The resulting paper, Adelman (1963) in French and Adelman (1964) in English, forecast that oil prices would continue to fall at least until 1980, as they did until 1970. After 1970, events obviously did not follow the pattern he anticipated. However, he clearly acknowledged this misjudgment after the fact (Hanke, 2014; Adelman, 1997).

A student's Ph.D. thesis, Zannetos (1966), furthered his knowledge of the competitive nature of the world tanker market. Adelman also turned to the study of petroleum engineering to understand production decline rates and reserve estimates. Engineering data combined with newly available investment data also allowed someone outside of the industry for the first time to compute the development costs of crude oil in several regions and, hence, characterize the economics of petroleum production (Adelman, 1966a, 1970, 1997).

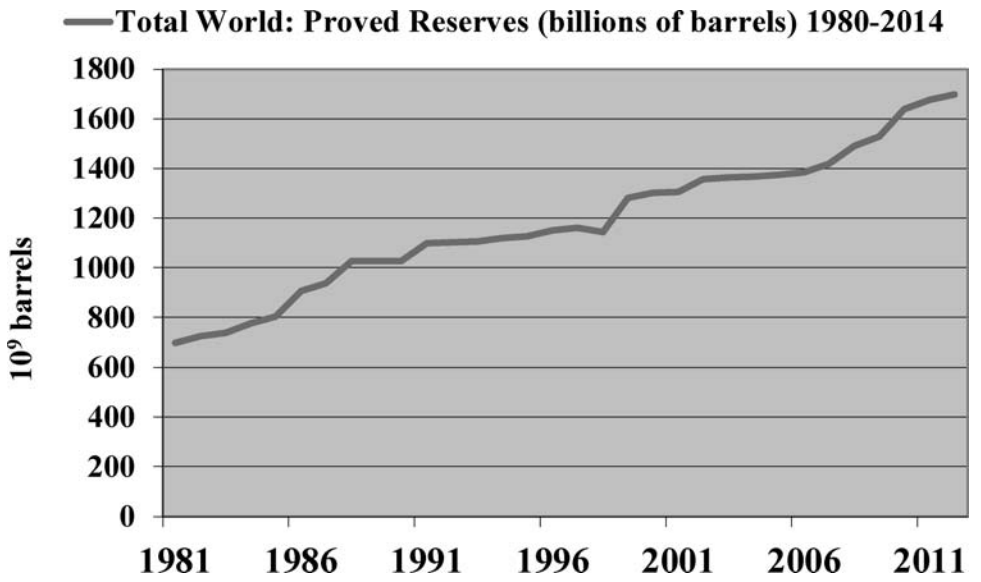
His *tour de force* and what sealed his fate to become the Dean of Petroleum (luckily for us he was too young to be shot) was his 1972 book, *The World Petroleum Market*. Although much has changed since that text was drafted, Professor Adelman captured in numbers and words, with a great care for detail, how the market had worked. The purpose of the book is acknowledged by Adelman (1972, 78) as "the ultimate object, now and always, is to explain and predict price behavior." He proceeds to measure oil and product price and discuss how they are influenced by cost as well as tanker rates, discoveries, politics, and market structure. This book continues his customary *modus operandi* of basing conclusions on correct institutional detail, basic economic theory, little

more math than basic business arithmetic, psychological understanding, and well-argued conclusions based on information painstakingly collected (Odell, 1973;, Yeager, 1974).

Ever the myth buster, Professor Adelman continued to argue that the world was not running out of oil and gas. (Adelman, 1972–73; Hanke, 2014). He argued that oil and gas reserves are not fixed as in a Hotelling (1931) world. Rather, oil and gas in place are fixed but unknown and unknowable. Reserves, in contrast, are developed. They are an inventory that can be built up by exploration and development and drawn down by production. Adelman and Houghton (1983) and Adelman (1983) deal with resource and reserve estimates. Costs represent a continual tug of war between depletion and new discoveries and new technology. Professor Adelman never wavered from this theory despite cyclical vilification by Peak Oilers and others living in a simple textbook-Hotelling world of fixed stocks that will come to be depleted one day (CEEPR, 2014; Lynch, 2014). Although he credits the genesis of this idea to Gordon (1967) and Herfindahl (1967a, 1967b), Adelman was the one who promulgated it relentlessly. He returned to this notion of reserves in many works including Adelman (1983, 1990a, 1997b) and Adelman and Watkins (2008).

Through the years he gave example after example, field by field, of how oil reserves have consistently increased, not decreased over time. We can see this same effect in the following graph from British Petroleum (2015), which shows reserves increasing over the course of thirty years from less than 800 to more than 1,600 billion barrels despite billions of barrels having been produced during the interim. The effect is even more dramatic if we go back further. API (1969) gives world proven reserves in 1947 as 73.6 billion barrels.

Figure 1



Source: British Petroleum (2015)

In considering policy and market structure, Professor Adelman credited the Seven Sisters with holding up international prices before World War II but measured their reduction of market power as competition from other large companies crept in after the War. He discussed the role of U.S. state commissions (especially the Texas Railroad Commission) in helping to shore up and stabilize U.S. prices through the 1950s and 1960s, a theme carried over from Adelman (1964). He traced the evolution of OPEC as it gained more teeth and eventually took over revenues and then

operations from the great multinational oil companies in the 1970s. Although there had been only a few nationalizations at the time *The World Petroleum Market* was published, he considered there might be more in the offing. However, he did not think it would be in OPECs interest to nationalize as it would turn the multinational oil companies into competitors rather than tax collectors and would increase competition.

He noted the role of OPEC in keeping prices high through taxation even as costs fell. From a policy perspective, he argued that U.S. and European governments sanctioned the price increases of 1971 as higher oil prices provided protection for any domestic energy industries whether oil, gas, coal, or nuclear power (Yeager, 1974).

Although he did not issue many policy prescriptions in the book, Professor Adelman did argue again for a strategic petroleum reserve (SPR), which he had earlier proposed in Adelman (1967). There he addressed the security of supply and first argued for oil stockpiles with a recommended six months' supply after Syria seized and shut down the pipeline to the Mediterranean Sea from Iraq. Since then many countries have instituted such stockpiles: The IEA has required members to develop oil stockpiles equal to 90 days of imports since its inception in 1975 (IEA, 2012). Since 2000, both China and India have implemented programs for strategic reserves. Professor Adelman argued such a policy would be cheaper and more effective than policies supporting more expensive coal, natural gas, and nuclear fuel sources (Langley, 1973).

Professor Adelman's 1972 book could not have come at a better time. It put him in high demand as a speaker just as the Arab Oil Embargo hit. He reiterated the theme that oil was not scarce and that the real energy problems come from withholding of supplies either by monopolies or governments, from the cost of high prices borne by the poorest countries, and from market failures due to energy-related pollution (Adelman, 1972–73; Adelman, 1973a; Adelman, 1974). He argued that lack of oil would not restrict population or economic growth although pollution from oil use might (Adelman, 1975).

More controversial were his proposals to sow confusion among OPEC members by having them bid against each other for import quotas to be purchased through a competitive bidding process. (Adelman, 1976a; CEEPR, 2014; Martin, 2014). Although a possibility, he did not think OPEC would retaliate with a coordinated selling group because of the high cost of dividing up market shares (Martin, 2014). However, OPEC's system of production allocation in effect from 1984–2009 (though not strictly adhered to) subsequently proved that OPEC was up to the task.

Important components for forming price expectations are wellhead costs, which for oil and gas include finding, development, and production costs. Adelman (1962) argued against the popular notion that oil and gas were decreasing cost industries. Although unit costs are not generally public knowledge in non-competitive industries, Adelman spent much time and effort ferreting out data, that in conjunction with basic economic theory provided useful indications of the real cost of petroleum supply. In Adelman (1964), he surmised how much higher was the cost of a barrel of U.S. oil than an imported barrel. This higher cost he attributed to prorationing by the Texas Railroad Commission and the U.S. import quota.

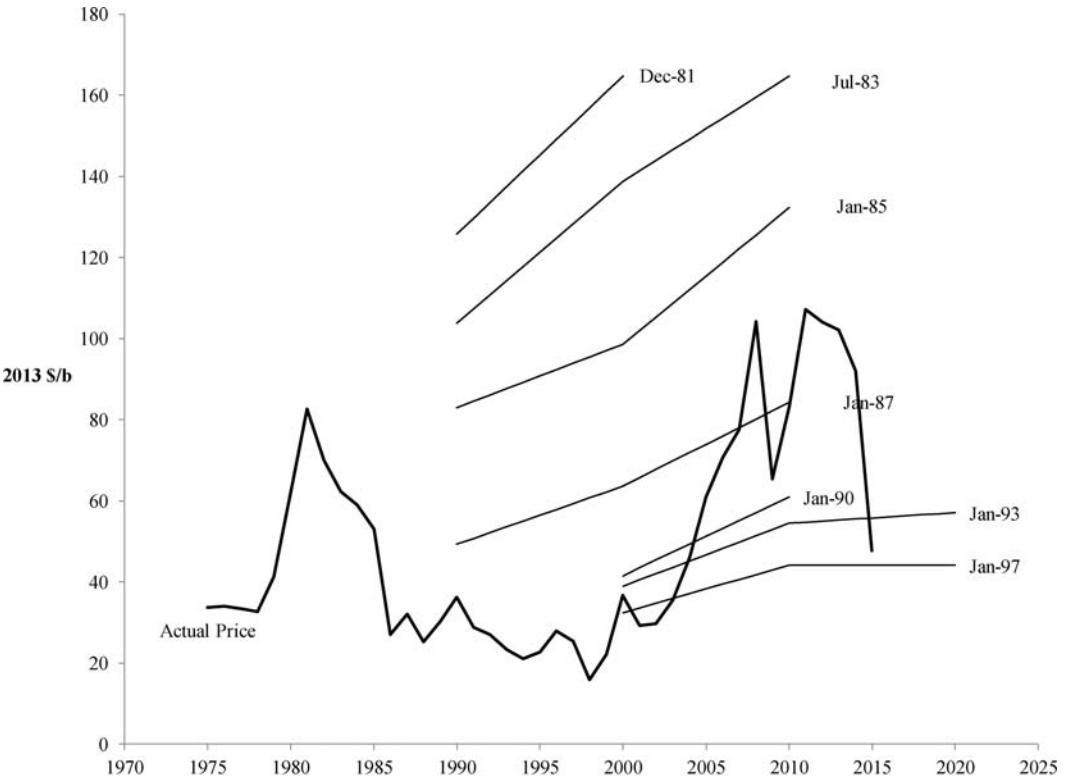
In Adelman (1966a), he computed per barrel costs for four areas—United States, Venezuela, Africa and the Persian Gulf, again showing how much lower were non-U.S. costs, while in Adelman (1971), he turned his attention to Alaska. The chapter on cost in Adelman (1972) outlined his methodology for computing levelized cost and updated his former computations for the four areas indicated earlier. Adelman and Ward (1980) considered cost per well and cost per barrel of capacity in the U.S., North Sea, and a number of other producing areas. Adelman and Shahi (1989) tackled the ambitious task of estimating per barrel costs for 41 oil producing countries across time with the longest series from 1955–1985, with some updates in Adelman (1992b, 1996a). U.S. costs were updated several times in Adelman (1985d, 1991c, 1991d, 1992f). When contemplating costs and economic decisions in the producing countries, he argued for high discount rates given the exporters' high economic dependence on the oil industry (Adelman, 1986a).

Through his cost computations, a constant theme was that technology was keeping ahead of depletion, costs were falling, reserves were abundant, oil and gas were not scarce (Adelman 1989a, 1991b, 1994b, 1996b). He found the same falling costs in Adelman (1998a, 1998b) with a slightly different methodology. There he fit a simple relationship using price (P) to proxy marginal cost, which is assumed to rise as a function of the quantity supplied (Q):

$$P = expbQ - 1.$$

He estimated b for periods and areas where he thought the market was more likely competitive (OPEC from 1949–1970, U.S. natural gas from 1984–1997, non-OPEC outside of the U.S. from 1970–1997), which justifies use of the proxy, and found b (an index of marginal cost) to be generally falling over time—tantamount to an outward shift in the supply curve. He repeated this computation for the U.S. for 1918—1997 and found b to be initially falling, even during prorationing, but trending upward a bit after 1975.

Figure 2



Source: Dahl (2015)

Adelman (1976b) acknowledged Hotelling (1931) as elegant theory worthy of academic recognition but did not feel that a fixed stock is a realistic characterization of mineral reality. Nor did he believe that the Hotelling implication that user cost (price minus marginal cost) rising at the discount rate contains much predictive power. This failure is demonstrated by the well-known diagram (Figure 2) from the International Energy Workshop (IEW) with oil prices updated through May of 2015. The straight lines represent successive (dated) forward price forecasts in real terms at 10-year intervals, compiled by the IEW. Their slopes show a telltale steady Hotelling increase

across time. The darker line tracks actual oil prices, which bear little resemblance to the forecasts. In typical Adelman fashion, when reality did not match the theory, he looked for an alternative explanation relaxing the fixed stock assumption in favor of reserves-as-inventory. Although he acknowledged the concept of user cost, Adelman (1970, 1974, 1976b, 1983, 1986b) and Adelman and Houghton (1983) all argued that user cost is zero or quite small.

He returned to user costs in other papers. Adelman et al. (1990, 1991) computed historical annual user cost (value less post-tax cost) for the U.S from 1955–1986. It was generally less than $0.35 a barrel before 1974, but varied widely from -$1.74 to + $5.60 between 1974 and 1986.

Adelman and Watkins (1992) noted that earlier empirical work failed to corroborate the so-called Hotelling Rule: the net price of a nonrenewable mineral should rise at the interest rate. Implicit in the Rule is the Hotelling Valuation Principle (HVP), which holds that the market value of a mineral reserve in the ground should equal its net price (price minus marginal cost) at the wellhead. Adelman and Watkins collaborated for many years trying to prove or disprove the HVP using econometric analysis on market prices of reserve transactions as a function of the oil and gas reserves included in the transactions. Adelman and Watkins (1992, 1993, 1995b) did not find support for HVP in Canada. Nor did Adelman and Watkins (1995, 1996a) or updates with revisions in Adelman and Watkins (2003a, 2003b, 2005a, 2005b) find support in the United States.

In their studies of the HVP, Adelman and Watkins warned against combining oil and gas into a barrel of oil equivalent (BOE) and included oil and gas reserves separately. However, if an aggregate hydrocarbon reserve value is desired, what is the best way to combine them? Adelman and Watkins (2002a, 2002b, 2004) noted that they are often combined on a fixed thermal equivalent. They argued this is inappropriate for two reasons: oil and gas are not perfect thermal substitutes, nor are the relative values of oil and gas constant over time. They rather urged the use of a Divisia Index instead of fixed equivalents based on either thermal content or price.

Since Professor Adelman believed that prices were determined by costs, market structure, and policy, a discussion of market power and cartel behavior is ever present in many of his articles. Within the U.S., state commissions, most notably the TRC, and the oil import quota from 1959–1973 performed the role of a cartel (Adelman, 1964; Adelman, 1972). In the international arena, the Seven Sisters acted as a cartel from 1928–1939 but their market power was consistently eroded after World War II as large independents entered the market. They were followed by OPEC, whose power became evident in 1971 (Adelman, 1972). Professor Adelman expected excess profits to lure competition to penetrate the market just as a camel with its head in the tent tries for more complete penetration. After each successive price rise, he downplayed the idea that the increase represented true scarcity, but consistently maintained that cartel power, often sanctioned or aided by inept consumer government rhetoric and policy, was responsible (Adelman, 1975b, 1976b, 1977, 1980, 1982b, 1993a, 1993b, 1994a, 1995).

Professor Adelman acknowledged the rationality of OPEC to cartelize in the attempt to extract the most benefits from their oil resources. However, given the difficulty of coordinating a dozen or so independent nations without the oil companies being there to coordinate production levels, he initially expected OPEC power to erode. Eventually, in Adelman (1986b), he acknowledged that the cartel was here to stay. However, since it was a clumsy cartel, it would not enjoy consistent success. The price might be expected to oscillate between the monopoly level on the high side and the competitive floor on the low side (Adelman, 1978, 1986c). Although at times prices might reach even higher levels, there would always be natural pressure downward (Adelman, 1985a). For the same reason, the market could be expected to be more unstable than under the large international oil companies and U.S. state commission control (Adelman 1982a, 1985a, 1985c). Nor did he see cyclical patterns of industry investment as being responsible for the instability in price (Adelman, 1992e). He repeatedly called for the judicious use of strategic petroleum reserves to offset any serious threats to economic security (Adelman, 1982a).

Another frequently repeated theme addressed the argument that agreements for special access to producing country reserves were a useful way to enhance energy security in consuming

nations. He undercut such arguments using the bathtub analogy. Since the world oil market is global and draws from one big pool (Adelman and Jacoby, 1977), a shortage anywhere is a shortage everywhere. He supported his argument with the example of the Arab Oil Embargo specifically directed at the U.S. and Netherlands in 1973–1974. Since oil is fungible, the reduction in supply did not hit the U.S. and Netherlands any harder than other countries because supplies were redirected always to the highest bidder (Adelman, 1984b, 1992c). In addition, since producing countries are sovereign nations, OPEC's enforcement powers were limited (Adelman, 1984a).

When Western Europe entered negotiations with the Soviet Union for large natural gas contracts in the early 1980s, U. S. opposition led to a flurry of research on international natural gas markets, including a big International Natural Gas Trade project at the MIT Energy Lab. Professor Adelman participated in all three units of this work: Adelman et al. (1986a) and Adelman and Lynch (1986b) for Western Europe; Adelman and Lynch (1986a) for Asia Pacific; and Adelman et al. (1985) for North America. In each case, the focus was on supply with attention to historical and institutional facts and the best cost estimates the data would allow. As ever, the judgment went against the hypothesis of pernicious resource scarcity, although governments may need to get out of the way to let the market operate.

Although much of Professor Adelman's work preceded the Internet, he always seemed to have an abundant supply of quotes and press clippings to persuade and support his arguments. He was a firm believer that those who did not know history "were destined to repeat it" and much of his work is put into historical context that details the history of the oil market. Adelman (1972) contains the first extensive chronicle of industry milestones, with running updates in Adelman (1988a, 1988b, 1990b, 1990d, 1992d). These latter papers as well as other work were incorporated into his second book, *The Genie Out of the Bottle: World Oil Since 1970*, which appeared in 1995.

Ever the free-marketeer, Professor Adelman was critical of policies that contravened the market when no market failure was present, including the imposition of U.S. natural gas price controls (Adelman, 1962), prorationing of U.S. crude oil output (wouldn't unitization be a better solution?)(Adelman (1972), and U.S. oil price controls (Adelman 1979). It should be noted, however, that he did argue for a progressive ad valorem tax to contravene OPEC's market power (Adelman 1978, 1986a).

III. ADELMAN AND THE PAPERS IN THIS SPECIAL ISSUE

Professor Adelman has mentored many. The papers included in this volume illustrate how his ideas, methods and search for truth can still inspire. We conclude this introductory article by considering how these papers relate to Adelman's work.

When discussing security and special access agreements, Professor Adelman often reiterated the one pool proposition. James M. Griffin updates this theme in his piece, "Petro-Nationalism: The Futile Search for Oil Security." He notes that countries still have not learned the bathtub analogy or recognized the public good-nature of oil security. China makes special access deals, while the U.S. maintains its oil export controls. Countries may also restrict foreign access to their reserves. Griffin argues that such actions presume there exists a fixed supply of oil and that the world oil market is not one but many regional tubs. Thus, regional access is thought to assure a share of the fixed assets in a region. Griffin uses historical anecdote, price evidence, and a simple numerical model with two producing countries to refute these premises. He contends that neither bilateral agreements nor oil independence will isolate us from disruptions in world oil markets, except under unusual circumstances such as wide scale war.

Oil and gas do not, according to Professor Adelman, represent fixed assets, but rather a dynamic inventory built up with investment, at a cost that is influenced by depletion, random discoveries, and technology. Additionally, he felt that technology was winning the battle and there

was never a real economic shortage of oil or gas. The recent U.S. surge in oil and gas production from shale is a notable vindication of this view. Svetlana Ikonnikova and Gürcan Gülen examine the economics of shale gas production in their piece. "Impact of Low Prices on Shale Gas Production Strategies." As they note, one-third of U.S. gas production in 2014 was from shale and the resource base indicates that figure could increase further. They also note that dry gas production has been increasing even as the drilling rate has fallen in many plays. This might be explained by drilling in better locations, better drilling technologies, or increased well productivity. In true Adelman fashion, Ikonnikova and Gülen dig deep into the existing data to help unravel the mystery. In particular, they use dry gas well data from the Barnett, Fayetteville and Haynesville basins to judge the contribution of infill drilling to increased productivity.

Although Professor Adelman mostly focused on world oil, he did make a few forays into the world of gas. Adelman and Lynch (1986b), for example, considered the European gas market and noted the significance of barriers to entry due to the concentration of large supplies. Adelman often made the point that we can predict what would happen in a competitive or monopoly market but outcomes in oligopolies such as in the European natural gas market are not clear cut or easily predictable. Rather, strategic interdependence will influence the outcome. Finn Roar Aune, Rolf Golombek, Arild Moe, Knut Einar Rosendahl, and Hilde Hallre Le Tissier demonstrate this phenomenon in their paper "Liberalizing Russian Gas Markets: An Economic Analysis." They build a stylized two period Cournot model to show what happens when new competitive resources such as U.S. shale gas enter the market and reduce future demand. Predictably, current production rises when the Cournot players are similar. However, when the two players have varying sized reserves, they find the counterintuitive result that a player with large enough reserves may produce less now in response to the lower current price. They find this same result when they simulate a somewhat more realistic model with Russia, Algeria, Norway, and the Netherlands as Cournot players up to 2050. They find that Russia, with its huge reserves, decreases current production in response to future demand decreases. We think Adelman would have enjoyed pondering over this result that flies in the face of conventional wisdom.

Professor Adelman was often critical of government policies and consistently argued against subsidies, whether they be for European coal (Adelman, 1966b) or other energy products. Adelman verbalized his objection as follows. "Subsidies in whatever form to energy production or energy conservation are a waste of resources, which we can ill afford." (Adelman, 1990c). Nathan Balke, Michael Plante, and Mine Yücel concur that oil product subsidies are a waste in their paper "Fuel Subsidies, the Oil Market, and the World Economy." They build a transparent world oil model with net oil exporters (fuel subsidizers) and net oil importers to measure the welfare effects of removing these subsidies. They find that reducing subsidies would lower world oil prices about 6% and unequivocally enhance welfare and non-oil GDP for net oil importers. Oil exporters also generally benefit from the reduction of subsidies, but may lose if oil demands and supplies are inelastic enough and exporters have a large enough share of the market. When calibrated to current market conditions, the authors find that the optimal subsidy for exporters is lower than current subsidies but might not be zero.

Market structure was at the heart of much of Professor Adelman's analysis of price. Philip K. Verleger, Jr. strongly follows this tradition in his paper "Structure Matters: Oil Markets Enter the Adelman Era." In it, Verleger traces Adelman's structural approach all the way back to pre-energy papers relating to the A&P grocery chain. Verleger argues that structural shifts, which he dubs "Adelman moments," aren't captured by econometric and other models. Rather he persuasively argues that all significant oil price changes since 1970 have been the result of structural changes in

markets. Such changes have included the peaking of U.S. oil production in 1970, the ending of the U.S. import quotas and prorationing in 1970s, the nationalization of assets in oil producing countries, the Iranian revolution, Saudi net-back pricing, oil production losses from the first Gulf War, supply reductions after the Asian Crisis, growing Chinese demand, increased sulfur restrictions that created shortages of distillate, global recession triggered by the U.S. subprime mortgage crisis, the Libyan revolution, the U.S. shale gale, with some discussion of potential climate policy. In Adelman fashion, he supports his arguments with facts and numbers. Adelman argued strongly for the judicious use of a strategic petroleum reserve. However, Verleger argues the U.S. SPR drawdowns that have occurred have not been judicious but rather were too little and too late.

As we noted previously, Professor Adelman continually expected OPEC to collapse and competition to rear its head in triumph. Although there were strains at times, OPEC did not collapse. Adelman (2001, p. 22) acknowledged the following "Though OPEC has been setting price for 30 years, its regime will not last another three decades." Verleger argues that another Adelman moment may have arrived when "The noncompetitive oil market may have ended on November 28, 2014, when OPEC announced that producers would no longer limit production." On the exhilarating stage of world oil, we can only wait to see if this Adelman-Verleger moment is transitory or longer lasting.

Ever since Hotelling (1931) characterized non-renewable resources as fixed stocks to be eventually exhausted, a fixed stock and the resulting "r percent rule" have served as the foundation of much of the basic economic theory of non-renewable resources. Professor Adelman argued long (as early as Adelman, 1970) and loudly against the notion that such resources were fixed and exhaustible in favor of the notion that reserves were inventories developed with hard work and investment, and that resources would never be physically exhausted. They would, however, be economically depleted only when their development no longer paid a required return. Adelman (1990a) presents one of the more complete treatments of this alternative theory. It is the starting point for Robert D. Cairns and Graham A. Davis in their paper "Mineral Depletion and the Rules of Resource Dynamics" They indicate that Adelman (1990a) is "replete with insights on optimal resource management." Their task is to fit Adelman's verbal descriptions into the wider mainstream of economic analysis. They first note that if we relax the fixed stock effect, rules developed for renewable resources with reserves allowed to increase provide more appropriate insights. If we further allow for variable costs as a decreasing function of stocks, an r percent rule holds but r should equal capital gains on the marginal unit of stock plus the change in the growth rates of the stock, plus the normalized reduction of unit costs from the addition of a marginal unit of stock. They note this mathematical interpretation is in accord with Adelman's verbal conclusion that the discounted return from extracting the marginal reserve should be equal for every year of extraction. With the addition of uncertainty (clearly an important feature in the oil industry) the r percent rule would also include a risk premium. Adelman noted that resources are not homogenous, with higher quality reserves to be depleted first, that shocks emanate from discoveries and technology, that investment is lumpy and irreversible, and that exploitation may continue in the face of loss due to the option value of later potential profits. Davis and Cairns develop these assertions with more formal modelling and vindicate many of Professor Adelman's insights.

Adelman and Watkins (2004) were critical of the concept that gas could be measured in terms of barrels of oil equivalent (BOE) for any useful purpose. Although revenues from oil and gas sales are relatively easy to untangle, the joint costs of development are not, which means there can be no final escape from the problem of aggregation. However, thermal equivalences are not the obvious answer since the value of heat is partly dependent on the type of fuel from which it is

produced. Adelman and Watkins concluded that the use of BOE overstated the cost of reserve additions by about 10% from 1982–2002. Measures of equivalence based on the terms of trade between fuels better represent the economic value. James L. Smith continues and updates this approach in his paper "Valuing Barrels of Oil Equivalent" He notes that, despite obvious deficiencies, thermal equivalence is widely used to measure aggregate production, reserves, and resources, as well as to scale financial aggregates such as revenue, cost, and taxes. Like Adelman and Watkins, Smith argues that oil and gas prices are a better measure of economic value, noting that the distortions implicit in thermal equivalence are likely even wider now than in 2004 since oil and gas prices have diverged even farther from thermal equivalence.

Smith begins his evaluation by assuming that the total reported value of reserve transactions can be separated into separate components for oil and gas, and that the ratio must be related to the relative prices of the two fuels. In true Adelman fashion, he then goes to transactions data to compare the aggregate reserve values based on thermal equivalents to a simple alternative based on economic equivalence. Not surprisingly, interesting patterns emerge that distinguish the two approaches. He also demonstrates the impact of the method of aggregation on inferred levels of finding and development costs, production costs, operating margins, and even on industry benchmarking analysis performed at the company level.

Governments, usually the owners of underground mineral and hydrocarbon resources, have had their fingers in the hydrocarbon till for decades. Adelman (1972) chronicled the struggles over taxes between the oil producing countries and the large multinational companies. He said of the producing countries, "They're just trying to do the best for themselves, squeezing the goose without killing it" as quoted by Martin (2014). Although those struggles became moot with nationalization, the struggle continues wherever companies can bid for access and subsequently pay taxes. Adelman (1986d) also noted that taxes on marginal fields cause premature abandonment, effectively killing the goose, and indicated that lower taxes might actually increase tax revenues and save the goose for a later day. Petter Osmundsen, Magne Emhjellen, Thore Johnsen, Alexander Kemp, and Christian Riis note this same tension existing today in Norway in their paper, "Petroleum Taxation Contingent on Counter-factual Investment Behaviour." They argue that 2013 changes in Norwegian tax law might just be putting some geese at risk. They portray the government as the principal charged with taxing oil companies (agents) in a way to maximize government revenues while not distorting the optimal production profile that maximizes resource value.

They note that in a perfect world, a tax on cash flow should be non-distorting and for Norwegian exploration, costs may be deducted as incurred. However, for development, costs must be depreciated over time. Since this would otherwise cause underinvestment in development, the Norwegian government (and other governments) give an uplift or tax-free allowance as a certain percent of development expenditures for a specified number of years. The 2013 tax change in question was a reduction in the allowed four-year uplift rates from 7.5% to 5.5%. The government's rationale for the change was a suggestion from theory that companies may use a lesser discount rate to value tax liabilities because taxes are riskless. Government estimates also suggested that an even lower uplift of 2.2% should suffice. In true Adelman fashion, the authors argue that companies using different discount rates for different cash flows, called partial discounting, "just ain't so." They site evidence in support of their assertion and further note it is unlikely that companies view tax flows as being free of risk. They bolster their arguments that the new law will cause lower investment by applying NPV analysis to a typical field as well as comparing recent tax changes in the UK and Australia.

Professor Adelman certainly understood the power of competition and markets. Although OPEC never broke ranks to the extent Adelman expected, outside of OPEC he often illustrated

how entry eroded power. Charles F. Mason corroborates this tendency in his paper, "Concentration Trends in the Gulf of Mexico Oil and Gas Industry." Mason first characterizes trends in overall oil and gas production in the Gulf. It generally rose from 1980–2010 as U.S. oil production elsewhere was falling, although the pattern reversed after 2010. Oil reserves followed a similar path. Gulf gas production more generally fell over the whole period. Mason finds oil reserves are generally being depleted faster in the Gulf, and with a migration to deeper waters as technology improved. Although the original Seven Sisters controlled more than 80% of production in the deepwater Gulf in 1996, their share had fallen to under 60% in 2014. The fall in percentage points for oil was about the same for shallow water Gulf but starting from a lower level of concentration. He also finds the number of firms producing oil and gas in the Gulf generally flat or falling from 1995–2013.

As Adelman would have done to more formally consider concentration changes, Mason goes back to the data. Using standard indexes, he measures market concentration. On annual data from 1980 to 2014, he found lease concentrations never attained the threshold level that would indicate undue market power. Further, he measures concentration in oil and gas production by depth using monthly data from 1995–2014 and finds that deepwater gas and oil production concentration ratios have fallen steeply over time. Concentration of production in shallow water was always generally low. After also examining the identity of winning bidders for offshore tracts from 1955–2014, he generally finds much entry, exit, and shuffling among firms listed as the most active in these lease sales, which might reflect the impact of joint bidding and which may help to sustain a low level of concentration.

Professor Adelman ever strove to understand the price of oil and considered cost as an important but not the only determinant of price. He saw also that the price of oil would impact its cost through its impact on exploration for and development of reserves. And, the whole process would suffer from random shocks. Gerhard Toews and Alexander Naumov formulate a structural model of upstream activity that incorporates just these factors. Their paper, "The Relationship Between Oil Price and Costs in the Oil Industry," examines the time series variation in oil price, development cost, and drilling rates. By adopting a structural vector autoregression, they are able to identify the strength and direction of causal relations that tie these variables together, and also to measure the speed of industry adjustment to shocks on the system. They find, for example, that a 10% shock to the price of oil increases drilling rates and costs by roughly 3.5% within 12 to 18 months, but with the impact on drilling rates much less persistent than the impact on drilling cost.

So Professor Adelman, we close this introduction by saying we miss you, we salute you and we offer up the following papers in your honor.

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