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The New York Times was wrong; Russian uranium deals don't threaten world supply security.

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A recent article in the *New York Times* notes that the Russian state nuclear corporation Rosatom and associated firms are gaining control of a growing number of uranium resources and mining operations. The article, headlined "Cash Flowed to Clinton Foundation Amid Russian Uranium Deal (http://www.nytimes.com/2015/04/24/us/cash-flowed-to-clinton-foundation-as-russians-pressed-for-control-of-uranium-company.html)," focuses on donations to charities connected to former US President Bill Clinton and his family, made by businessmen who stood to profit from the sale of Uranium One, a Canadian company with worldwide uranium-mining interests. Because uranium is a strategic commodity and some of the company's holdings are located in the United States, the Uranium One deal had to be approved by several US agencies, including the State Department, then headed by Hillary Clinton.

Notably, the deal highlighted in the article—which took place in three separate transactions between 2009 and 2013—gave the Russians ownership of 20 percent of the uranium reserves located under US soil. The *New York Times* article was premised on the suggestion that the Uranium One sale might pose a strategic threat to the US and other countries that rely on nuclear power for electricity production, if Russia were to use its control of the market to increase prices or restrict production or export of uranium for political purposes. The *Times* article contends that "[t]he deal made Rosatom one of the world's largest uranium producers and brought [Russian President Vladimir] Putin closer to his goal of controlling much of the global uranium supply chain" and calls Putin "a man known to use energy resources to project power around the world."

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A multi-player, boom-bust market. Russia is a significant but not dominant player in uranium markets. Less than four percent of current world uranium production and nine percent of world uranium reserves are on Russian soil. Adding foreign mines and deposits that are controlled by Russia increases this total to about 14 percent of production and 12 percent of reserves, but these foreign assets—particularly those in the United States—are far less susceptible to political or economic manipulation by Russia than are its domestic resources.

(https://co.clickandpledge.com/sp/d2/default.aspx?wid=54382)

Uranium is widely viewed as a strategic commodity, and actions to secure resources beyond state borders are far from unique to Russia. In the past decade, China has purchased stakes in uranium deposits (http://www.wise-uranium.org/uccnn.html) in Africa, Central Asia, and Australia representing some 500,000 metric tons (http://bos.sagepub.com/content/71/3/58.full.pdf+html) (or tonnes) of uranium in the ground. The French multinational AREVA has a long history of investing in uranium projects across the world, notably in sub-Saharan Africa. In fact, AREVA and the Chinese National Nuclear Corporation are negotiating a partnership at one planned mine, Imouraren (http://www.wise-uranium.org/upne.html#IMOURAREN) in Niger. Plans to begin producing from this 210,000-tonne deposit are on hold, however, due to excess supply and falling prices. To put these resources in perspective, total world uranium demand is currently about 60,000 tonnes per year.

In general, attempts to control access to strategic commodities are self-defeating because they raise prices, stimulating more efficient use in the short term and additional production in the longer term. This has been true even for commodities with no readily available substitutes. OPEC's attempts to control oil markets led to a tenfold increase in the real price of oil (http://www.eia.gov/petroleum/data.cfm#prices) between 1970 and 1980, but the high price stimulated the development of oil resources in other countries, as well as technological innovations, such as the horizontal drilling and hydraulic fracturing techniques which have made the United States the world's largest oil producer. More recently, China's attempts to limit export of rare earth elements led to renewed production in the United States and Australia and increased production by other countries, resulting in price drops of 70 percent to 90 percent from peak values reached in 2010 and 2011. Domestic production, which was essentially zero as recently as 2011, supplied 41 percent of US demand in 2014 (http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/mcs-2015-raree.pdf).

The world uranium market has exhibited similar behavior. A commodity market for uranium began to emerge in the 1970s. Since then, the uranium industry has undergone two boom-bust cycles. Early expectations for the rapid growth of nuclear power drove the uranium spot price to an inflation-adjusted high of $350 per kilogram of uranium in 1977 before gradually collapsing to less than a tenth of that value 15 years later. (All prices are adjusted to 2015 dollars, using the US Bureau of Labor Statistics Consumer Price Index.) A second boom, induced in part by exhaustion of stockpiles built up as long ago as the 1970s and expectations of a nuclear renaissance, saw uranium spot prices briefly touch nearly $400 per kilogram in 2007. Prices quickly declined from this peak (http://www.neimagazine.com/features/featurehistory-as-prelude-the-outlook-for-uranium/), reaching $110 in 2009. The spot price as of the end of April 2015 was $100. (US utilities satisfy 80 percent to 90 percent of their requirements through long-term contracts, which are substantially less volatile. The average price utilities paid for their uranium (http://www.eia.gov/uranium/marketing/pdf/2014umar.pdf) during this period did not exceed $150 per kilogram.)

This cyclical behavior is typical of commodity markets; in the case of uranium, there is no evidence of the sustained upward trend in prices that would be expected were the global resource becoming scarce or increasingly costly to prospect and extract.

US uranium production did not rise substantially in response to this price boom, but domestic production has long played a minor role in meeting US uranium demand. According to the Organization for Economic Cooperation and Development (OECD) and International Atomic Energy Agency (IAEA) uranium industry surveys—the so-called Redbooks—annual production in the US peaked in 1981 (https://www.oecd-nea.org/ndd/pubs/2014/7209-uranium-2014.pdf) at 17,000 tonnes and has generally remained below 2,000 tonnes since 2000. This decline is not associated with the depletion of US uranium deposits. To the contrary, at 472,000 tonnes, US reasonably assured uranium resources--a standard measure for such deposits—are the second largest in the world. Only in Australia is more uranium—1,208,000 tonnes—known to exist in this highest-confidence resource tier.

The US is not currently a major producer of uranium for two reasons. First, from the dawn of the nuclear era through the early 1980s, world uranium production consistently outstripped demand (http://www.world-nuclear.org/info/nuclear-fuel-cycle/uranium-resources/uranium-markets/). In 1980, nearly 70,000 tonnes were being produced annually while annual civilian plus naval military demand was around 40,000 tonnes. As uranium demand leveled off in the late 1980s and early 1990s, uranium prices collapsed, followed shortly by a corresponding collapse in uranium production. By 1992, world annual production had dropped to less than half of its peak value. As noted above, the inflation-adjusted uranium spot price had also fallen from over $350 per kilogram in the late 1970s to less than $40 in 1992.

This price crash led to a sharp reduction in uranium mining in the United States because producing uranium from most US uranium deposits is a relatively costly proposition. Less than 10 percent of US reasonably assured uranium resources can be mined at a cost of less than $80 per kilogram, compared to 70 percent for Canada and 54 percent for Kazakhstan, the world's two largest producers, according to the 2014 Redbook. As a result, only a few US uranium mines remained competitive at low prices. Although it did lead to substantial expenditures on exploration, the uranium price boom of the last decade was too short-lived to justify tapping costlier-to-mine US deposits and ushering in a new era of large-scale US production.

In the short to medium term, it is unlikely that US uranium production will expand substantially. Discoveries of high-grade deposits in other countries have more than kept pace with extraction. Since reliable record keeping began in 1965, identified uranium reserves have increased by over 4 million tonnes (https://www.oecd-nea.org/ndd/pubs/2006/6096-40-years-uranium.pdf), even as more than 2 million tonnes of uranium were extracted. Identified reserves stand at 7.6 million tonnes as of 2014, according to the 2014 Redbook. These reserves would be enough to satisfy world demand for over 100 years at current rates of consumption.

Uranium is not likely to become scarce or controlled by one country. In spite of this evidence of past and present abundance, are there signs that uranium may become scarce? If uranium were becoming scarcer, it should be increasingly difficult and costly to find more of it. Likewise, deposits being mined should be of lower quality over time, as the most attractive resources are exhausted and not replaced with high-quality discoveries. Neither of these trends is observed.

The average cost of discovering a kilogram of identified reserves can be inferred from Redbook data on exploration expenditures, reserves, and production over time. Between 1972 and 2013, the average cost of discovering a kilogram of proven reserves was just $6 per kilogram (in constant 2015 dollars). This cost has declined over time, from an average of about $7 per kilogram from 1972 to 1992 to $5 per kilogram from 1993 to 2013, according to the Redbook Retrospective and more recent Redbooks. The average uranium oxide content of ore being mined around the world has held nearly steady at 0.1 percent (http://www.thesustainabilitysociety.org.nz/conference/2007/papers/MUDD-Uranium-Mining.pdf) since the 1950s. If new discoveries of attractive deposits were not keeping pace with extraction, the ore grade would be dropping over time.

Past experience does not guarantee future abundance, and existing identified reserves could be depleted in several decades if nuclear power were to expand dramatically around the globe. But the existing identified reserves do not constitute all the uranium that is available. In the 1970s, geologists Kenneth Deffeyes and Ian MacGregor published an estimate of the distribution of the roughly 80 trillion tonnes of uranium in the upper 25 kilometers of the Earth's crust. Their estimate, which is still widely cited, established a relationship between the concentration of the uranium in ore and the amount available at that concentration. Subsequent analyses refined and updated this work and show that if the average grade of uranium being mined fell by a factor of three—probably with a commensurate rise in production costs and prices—the resource base would expand (http://utexas.influuent.utsystem.edu/en/publications/longterm-uranium-supply-estimates(0e913180-25cf-4449-ad95-e42fb9c4f445).html) by a factor of 10 to 30. This would be achieved by tapping into deposits that are currently uneconomic and therefore poorly prospected, such as phosphates and shales.

Finally, research and development of technologies for recovering uranium from seawater continues in the United States, Japan, and China. The 4 billion tonnes of uranium in seawater constitute an essentially limitless resource, and one that would be available to most countries. Because the uranium is present at a very low concentration—about 3.3 parts per billion—innovative passive collection techniques using uranium-selective adsorbents are being developed. Recent estimates place the cost of recovering uranium from the oceans (http://utexas.influuent.utsystem.edu/en/publications/review-of-cost-estimates-for-uranium-recovery-from-seawater(6ac42113-cb48-4db4-b54b-9e8f582a27b5).html) at several hundred to $1,000 per kilogram of uranium. Costs would be expected to decline as the technologies advance.

For all of the aforementioned reasons, a future of sustained uranium scarcity is extremely unlikely. The impact of a moderate price rise, if temporary and due to an attempt to control the market, or even if sustained due to resource pressures, would be modest. Uranium represents a small fraction of the cost of nuclear-generated electricity—about $4 per megawatt-hour at current uranium prices (http://www.eia.gov/uranium/marketing/html/table1.cfm), with reasonable assumptions about average fuel enrichment, burn-up rates, and other variables associated with nuclear generation of electricity. Thus, a doubling of the price of uranium would in fact add less than $4 per megawatt-hour to the cost of nuclear electricity as utilities would adopt efficiency measures discussed below. For comparison, the average retail price of electricity in the United States (and most countries with nuclear reactors) is more than $100 per megawatt-hour. Therefore, even if a sustained, moderate increase in the price of uranium did occur, it would not significantly affect the economics of nuclear power relative to other technologies, and it would have little or no impact on the price of electricity paid by consumers.

An attempt to restrict production or export of uranium could lead to a price rise in the short run. But this would trigger increased production at existing mines as well as efficiency measures that could be put in place almost immediately. The most notable efficiency measure is to lower the "tails assay," that is, the amount of easily fissile uranium 235 in the depleted uranium that is rejected from an enrichment plant. Around the world, the average uranium 235 content of such depleted-uranium tails stood at around 0.33 percent in 2004. (The U-235 content of natural uranium, in weight percent, is 0.711 percent.) By 2011, in the immediate wake of the price boom, it had fallen to 0.22 percent. By letting less uranium 235 pass into the tails waste stream, utilities and uranium enrichers reduced their natural uranium requirements by 20 percent in a very short time.

In the longer term, an increase in the price of uranium would encourage exploration and development of new mines around the world, undercutting any attempt to control the market. Therefore, although expanded control by one country can lead to short-term price spikes, such a spike in uranium prices would not present a danger to the economy as a whole, or even to utilities that are heavily dependent on nuclear power. Globally, uranium supply and reserves are adequate and will remain so. Market forces will act over the medium to long term to expand production, exploit existing reserves, discover new resources, and reduce prices. The Russian government will have little control over these dynamics.

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trevmc • a year ago

I think old Vlad carries a lot of weight in Kazakhstan, something to keep in mind when quoting Russian reserves. Yes, the world has an abundant supply of Uranium, seawater is full of the stuff, at about $300 pound it would be viable to hold your breath on that. What you have not mentioned is that ' been entering into long term contracts for the last few years ıe spot market, a very risky game in my ica's power supply is nuclear. To make ɛd to dump some of their uranium stockpile y dumb move. You can always trust a an to make the stupidest decision at the of Gordon Browns brilliant decision to dump d didn't that work out wonderful, it cost his ent animal with 20% of your power supply at he next few years John Snow.

ɔf the stuff. I guess I will wait a little longer to

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