The Future of Proven Oil Reserves

The usual explanations for the decline and fall of the Roman Empire include such things as political corruption, inflation of the currency and the heightened incursions of the barbarians. However, Fagan (2004) gives a more compelling reason that may explain the Ward-Perkins (2006) data on the reduction in the production of Roman Baths starting in the Northern Regions of Rome. What Fagan says is that weather patterns changed with a slow cooling starting in northern Europe and moving south. Furthermore, this cooling made it such that northern Roman regions could no longer produce as much wheat as before but instead had to produce millet, which was more resilient to the cooler wetter weather but which also reduced the productivity of those regional farms. This transition from wheat to millet reduced the output of the Roman economy and in turn the tax base from which Rome could collect, which weakened the state and resulted in the Crisis of the Third Century. This slow decline and fall of Rome is in stark contrast to the very striking decline and fall of the Soviet Union as explained in Reynolds (2016) where a peak in oil production is the clear and decisive factor of its collapse.

However, the surprising fact about the Soviet Empire's history is not so much that the Soviet Union fell (officially twenty five years ago on December 25, 2016) as much as it survived for over 70 years in the first place. This suggests that the rise and fall of the Soviet Union has more to tell us about economics than meets the eye. One explanation that may help explain Communist history is the stroke of luck behind Soviet economic expansionary success: the abundance of Soviet energy resources available, particularly oil resources. However, the bane of the USSR's economic demise was Soviet peak oil as Reynolds (2000) and Reynolds and Kolodziej (2008) explain. This means that oil production often increases at first but then decreases—i.e. there is a tendency for a peak in oil production as Soviet peak oil attests—which is a very powerful economic force in any economy. This is the Hubbert (1956a) curve, which needs to be considered forthrightly by all economists.

Fortunately, today the world does not appear to be close to any peak in oil production as the supply has increased by roughly 10% since 2009, contrary to Reynolds (1999b) initial prediction. This gives credence to resource optimists such as Adelman and Lynch (1997), Simon (1998), Lynch (2002), Brandly (2004), Bartlett (2004), Maugeri (2004) and Jahoda et. al (1973) that technology and economic innovation can overcome any scarcity of natural resources including energy scarcity. Resource pessimists such as Deffeyes (2001), Goodstein (2004), Hall and Klitgaard (2012) and Bardi (2011) still contend that resource scarcity—particularly oil scarcity—will pose a problem for the economy. Plus, Reynolds (2011) shows that, so far, most civilizations, up to and including the Soviet Empire, have not successfully overcome a peak in energy supply, although, one can argue that Russia carried on after the fall of the Soviet Union with new technology. Still, it is clear that post Soviet Russia had to endure a substantial reduction in its standard of living, as did Rome in its day and as we are likely to do in our day. Indeed, we may have already begun to experience economic decline as Cowen (2011) explains.

Nevertheless, many energy economists do not believe in peak oil even though the economic theory behind the Hubbert curve is well established in Reynolds (2009 and 1999a), with empirical and experimental work in Bardi (2005 and 2007) and Jakobsson et. al (2012) although, ameliorated with the idea that multi-cycles can and do exist (see M. King Hubbert

1962, p. 55, Hubbert 1956b, p. 10-11, Reynolds 2014; Reynolds and Zhao 2007, and Reynolds and Kolodziej 2009). I show the theoretical game in class. Therefore, the Hubbert curve theory should actually be in every textbook. Notwithstanding theory, this debate on oil scarcity is relevant again now that the latest estimate of proven oil reserves for the U.S., as posited by Nysveen (2016) and reported in Tencer (2016), which shows quite an increase in reserves, is bantered about. While the estimates of world oil reserves still suggest that eventually we will attain limits to growth due to oil scarcity, it also gives hope to resource optimists that there is still plenty of oil, particularly shale oil, for the foreseeable future by which time nuclear fusion or some other energy technology will create a new era of abundance.

Looking closely at the Nysveen reserve estimate, the evidence suggests that the U.S. has more oil reserves now than either Saudi Arabia or Russia, depending on what the true Saudi and Russian reserves are. While the new larger estimate may be accurate due to shale oil technology, giving resource optimists a fact upon which to hang their hat, there is nevertheless some confusion about what U.S. reserves really consist of. For example, one of the interesting aspects about this debate is the question of what oil is. That may sound like an unnecessary question since everyone believes they know what oil is, but it can be a more nuanced question than you think.

Consider past oil and gas statistics. According to DeGolyer and McNaughton (1979), in 1920 the U.S. produced 1.2 million barrels per day (MBD) of oil, which included about 2% of natural gas liquids (NGL). By 1950, the US production was close to 6 MBD and NGLs consisted of 8.4% of the total. By 1970 we were at 11.3 MBD with NGLs consisting of 14.6%. Also according to EIA (2002), the NGL production in the U.S. went from about 15% of total oil in 1970 to 25% in 2000. Lately liquid petroleum gas (LPG) has gone from 14% of the combined gasoline and LPG consumption in 2008 to 21% of combined consumption by 2014. Not only that, but over the last decade LPG production and consumption have increased by 22% even as LPG prices have decreased. In contrast, gasoline consumption has decreased by 3% partly due to high gasoline prices. That being the case, why has there recently been, relatively, so much LPG supply availability, even though its price has been low, and so little gasoline supply availability, even though its price has been high?

In addition, since about 1950, NGLs and crude oil were often put together into one statistic often called "oil." That method of comingling the identity of liquids production saves a lot of confusion for the general public so that they did not have to become petrochemical experts just to be able to understand basic oil market statistics, which can and do affect the economy. In addition, other economic agents, such as gas station chains that might buy oil futures for a certain purpose or bakeries that use propane or fuel oil and have to make contracts, also like a simple oil statistic. In general, NGLs were not a large part of the oil and gas market and were therefore assumed to be able to be melded together into a general oil market statistic. Then NGLs and LPGs could be priced at a certain percentage below a given WTI oil price, which worked well as long as there was plenty of mid-weight crude oil to go around.

But now we have shale oil, and shale oil is not always high valued mid-weight crudes of oil but often include lower valued light crudes and NGLs. So that brings us to the statistic that the U.S. has 264 billion barrels of oil reserves. The question is, what are those reserves exactly? Are they natural gas liquids with a lot of propane or are they more valuable mid-weight crudes or both? This is like asking the question, was Ancient Rome producing more wheat or more millet in 250 A.D.? Even though they sound the same and are measured in the same way, they are in fact quite different from a nutritional point of view and, more pertinently, from an economic point of view. The question becomes important because oil was just recently at a $100 per barrel price ($16.6 per mmbtu) at the same time when propane was selling for $1 per gallon (or $10 per mmbtu); an energy price differential of about 60% and a price differential that still persists, with oil recently at $8 per mmBtu and propane at $5 per mmBtu. The U.S. oil reserves statistics, then, make it sound as if the U.S. has 264 billion barrels of valuable mid-weight crude oil, period, when it could be that we have mostly less valuable NGLs. This is an important point and it goes to the heart of the question of whether peak oil is real or not.

The problem is that not many people in the general economy are going to understand the nuance between NGLs and mid-weight crude oil, kind of like trying to decipher and understand the nuance between a Rembrandt and a Vermeer work of art. Although the difference in painting can be hard to decipher, the difference in price at an auction can be quite substantial. Likewise, the difference between NGLs, light crudes and mid-weight crudes can make a big difference in economic productivity. Even some pentane and hexane hydrocarbons are going to be difficult to use for producing motor gasoline in the summer, which makes an even murkier oil reserves picture. Peak oil may not be peak oil after all, it may be peak mid-weight crudes, but most people will not comprehend the difference or the significance.

On the one hand, we know that Germany, Turkey and other locations use propane and even butane for automotive fuels so it does seem rather easy to be able to use light crudes for transportation purposes and, therefore, that NGLs, light-crudes and mid-weight crudes are all oil. However, there will need to be major infrastructure adjustments to be able to use propane and butane for automotive travel. Furthermore, important machinery, such as farm machinery, will not easily be able to use such fuels, and this can make farms or other economic entities less effective. This can reduce the productivity of the economy, and the transition is likely to be jerky rather than smooth.

On the other hand, you can always use pure natural gas (methane) to run automobiles, although, as Flynn (2002) shows, natural gas propulsion systems have so far not been very successful. For example, Utah (Krauss 2008) appeared on the surface to have put up a successful natural gas vehicle fuel system, but upon close inspections the details show the realities of long lines, waiting for fill-ups and a lack of supplies at crucial times. Such systems often encounter bottlenecks, due to the high costs of the infrastructure to provide the fuel, that gasoline and diesel systems have never had to contend with since the days of the 1970s oil crisis. Bottlenecks in supply, and other distribution problems may be worthwhile if the fuel is cheap, but that implies a cost to economic efficiency which is the whole point of resource scarcity.

Some might also argue that most if not all NGLs can be made into gasoline and diesel products using such process as polymerization and dehydrogenation, although as A. Abazajian (2016) shows these processes can be expensive and can have bottlenecks associated with them. Plus new gasolines from NGLs often have less BTUs per gallon and are more volatile chemically and so require chemical stabilizers. Alternatively, some engineers envision using propane or natural gas self-driving cars that can fill-up all night long in order to be prepared for the rush hour traffic in the morning, like an army of taxi drivers. What is missing is the idea that these systems too have their problems. For example, Queenan (2016) brings up the idea that these cars can be hacked and made to kidnap you, or worse yet, they can all be remotely commandeered to drive right into the propane or natural gas filling stations in order to strategically destroy infrastructure.

They also require significant economies of scale. When you have large economies of scale, you get a natural monopoly that tends to become socially inefficient. For example Vanderbilt's New York Railroad, Gates' Microsoft and Rockefeller's Standard Oil all had one thing in common, they built innovative, cost effective products, but they made most of their money by gaining monopolies in their respective markets. At first, such monopolies are good for society creating innovation and reducing costs, but later on they become less effective. Regulation and government ownership are two solutions to reducing monopoly costs, but those solutions are not necessarily efficient as governments are slow to reduce bottlenecks within such systems whether as a regulator or as an owner.

People may think that electric cars like Tesla's will lead the way, but compared to a Tata Nano, a Tesla, even if its price can be reduced by half, could not compete; and theoretically if a Tesla can be made cheaper, than so can a Tata Nano. The only reason the Tesla is in any way competitive now is because the average American automobile is over-priced with features that are unneeded, but which could be removed with little harm, such as super-sized engines with super sized cabins. Indeed, we may have a car bubble.

So, it's not a question of what energy is possible to use, but a question of what economic costs will be involved in changing over to a new energy system, as the Soviet Union itself shows. In the Soviet Union's case, there was a decisively quick peak and decline of its primary energy resource, oil, and then its economy fell. In Ancient Rome's case, there was a more nuanced slow motion peak and decline of its primary energy resource—wheat—that caused its economic crisis. We will probably encounter something between the Soviet case and the Roman case probably faster than Rome's fall but possibly a bit slower than that of the Soviet Union's fall. Although, given the fact that many conventional oil fields can decline as fast as 7% per year and that shale oil fields can decline as fast as 30% per year, and can experience severe bottlenecks when the industry tries to increase shale production, then the Soviet case could be the closer case study than the Roman case. Nevertheless, in both situations there was hyperinflation (which I would define as anything faster than about a 30% increase in price levels per year, contrary to the text book definition of anything greater than 30% per month), which can help loosen restrictive labor markets during such a crisis. This makes the Energy Information Administration's job, never mind the Federal Reserve's job, the Treasury Department's job and the U.S. Mint's job, quite the challenge. Regardless, society must be prepared for hyperinflation, although, such hyperinflation could help reduce social unrest and recessionary fatigue as it did in post-Soviet Union.

References

A. Abazajian, Advisian, (2016). “Consider high-value outlets for propane and butane,” Worley-Parsons Group, Houston, Texas; Found on the Web 08/16/2016, at Gas Processing News: http://www.gasprocessingnews.com/features/201606/consider-high-value-outlets-for-propane-and-butane.aspx .

Adelman, M.A. and M.C. Lynch (1997). “Fixed View of Resource Limits Creates Undue Pessimism,” *Oil and Gas Journal*, April 7, pp. 51 - 54.

Bardi, Ugo (2011), *The limits to growth revisited*, Energy series: springerbriefs in energy analysis. Springer Energy Series.

Bardi, Ugo (2007). “Energy Prices and Resource Depletion: Lessons from the case of Whaling in the 19th Century. *Energy Sources B: Economics planning and policy*, Volume 2, Issue 3, Pages: 297-304.

Bardi, Ugo, (2005). “The mineral economy: a model for the shape of oil production curves,” *Energy Policy*, Volume 33, Issue 1 , January 2005, Pages 53-61.

Bartlett, Bruce, (2004). "Doom-and-Gloomers say we’re near tapped-out of oil. Rubbish,” *Alexander’s Gas and Oil Connections*, Volume 9, Issue #13, June 29th, 2004, http://www.gasandoil.com/goc/features/fex42632.html.

Brandly, Mark, (2004). "Will We Run Out of Energy?” Blog, May 19, http://www.mises.org/fullstory.asp?control=1519 .

Cowen, Tyler (2011). *The Great Stagnation: How America Ate All The Low-Hanging Fruit of Modern History, Got Sick, and Will (Eventually) Feel Better*, Dutton Publisher.

Deffeyes, Kenneth, (2001). *Hubbert’s Peak: The Impending World Oil Shortage*, Princeton University Press, Princeton, New Jersey.

DeGolyer. E.L. and L.W. MacNaughton, (1979). *Twentieth Century Petroleum Statistics 1979*, DeGolyer and MacNaughton, Dallas, TX.

Energy Information Administration (2002). EIA, Petroleum Supply Monthly (February 2003).

Fagan, Brian, M. (2004). *The Long Summer: How Climate Changed Civilization*, Basic Books, New York.

Flynn, Peter C. (2002), “Commercializing an alternate vehicle fuel: lessons learned from natural gas for vehicles,” *Energy Policy*, Volume 30, pp. 613–619.

Goodstein, David, (2004). *Out of Gas: The End of the Age of Oil*, W.W. Norton and Company, New York, 128 pages.

Hall, Charles A. S. and Kent A. Klitgaard, (2012). *Energy and the Wealth of Nations: Understanding the Biophysical Economy*, 1st Edition., 2012, XIV, 407 p. Springer Energy Series.

Hubbert, M. King, (1962). *Energy Resources: A Report to the Committee on Natural Resources: National Academy of Sciences*, National Research Council Publication 1000-D, Washington D.C.

Hubbert, M. King, (1956a). "Nuclear Energy and Fossil Fuels," API Drilling & Production Practices. p. 17.

Hubbert, M. King, (1956b). "Nuclear Energy and Fossil Fuels," Publication #95, Shell Development Company, Exploration and Production Research Division, Houston Texas, June.

Jahoda, Marie, K. L. R. Pavitt, H. S. D. Cole, Christopher Freeman (Editors), (1973). *Models of Doom: A Critique of the Limits to Growth*, Universe Publishing.

Jakobsson, Kristofer, Bengt Söderbergh, Simon Snowden, Chuan-Zhong Li, and Kjell Aleklett (2012). "Oil exploration and perceptions of scarcity: The fallacy of early success." *Energy Economics*, Elsevier, vol. 34, number 4, pages 1226-1233.

Krauss, Clifford, (2008). "Surge in Natural Gas Has Utah Driving Cheaply," published August 29, 2008. Associated Press.

Lynch, Micheal C., (2002). "Forecasting Oil Supply: Theory and Practice." *Quarterly Review of Economics and Finance*, vol. 42, no. 2 pp. 373 - 389.

Maugeri, Leonardo. (2004). "Oil: Never Cry Wolf—Why The Petroleum Age Is Far From Over." *Science*, vol. 304, no. 21, May: pp. 1114 - 1115.

Nysveen, Per Magnus (2016). "United States now holds more oil reserves than Saudi Arabia," July 04, 2016, Head of Analysis, Rystad Energy.

Queenan, Joe (2016). "Self-Driving Cars Could Drive Us Crazy," Moving Targets Column, *Wall Street Journal*, Volume 268, No. 37, Page C11.

Reynolds, Douglas B., (2016). *Cold War Energy: The Rise and Fall of the Soviet Union*, sole author self-published academic monograph, Alaska Chena, 120 pages.

Reynolds, Douglas B., (2014). **"**World oil production trend: Comparing Hubbert multi-cycle curves," Ecological Economics, Volume 98 (2014) pp. 62–71.

Reynolds, Douglas B., (2011). *Energy Civilization: The Zenith of Man,* sole author self-published academic monograph, Alaska Chena, 440 pages.

Reynolds, Douglas B., (2009). Chapter 1, "Oil Supply Dynamics: Hubbert, Risk And Institutions," In: Pitt, Edward R. and Christopher N. Leung, Editors, *OPEC, Oil Prices And LNG*, ISBN:978-1-60692-897-4, Nova Science Publishers, Inc.

Reynolds, Douglas B. (2000). “Soviet Economic Decline: Did an Oil Crisis Cause the Transition in the Soviet Union,” *Journal of Energy and Development*, Volume 24, Number 1, pp. 65-82.

Reynolds, Douglas B. (1999a). “The Mineral Economy: How Prices and Costs Can Falsely Signal Decreasing Scarcity,” *Ecological Economics*, Volume 31, Number 1, pp. 155-166.

Reynolds, Douglas B. (1999b). “Oil Scarcity Should Be a Concern,” USAE Dialogue, Volume 7, number 1, pp. 12-13.

Reynolds, Douglas B. and Marek Kolodziej, (2009). “North American Natural Gas Supply Forecast: The Hubbert Method Including the Effects of Institutions,” *Energies* 2009, 2(2), 269-306.

Reynolds, Douglas B. and Marek Kolodziej, (2008). “Former Soviet Union Oil Production and GDP Decline: Granger Causality and the Multi-Cycle Hubbert Curve” *Energy Economics.* Volume 30, pp. 271-289.

Reynolds, Douglas B. and Yuanyuan Zhao (2007). "The Hubbert Curve and Institutional Changes: How Regulations in Alaska Created a U.S. Multi-Cycle Hubbert Curve," in *The Journal of Energy and Development*, Volume 32, Number 2, Spring 2007, pp. 159-186.

Simon, Julian L. (1998). *The Ultimate Resource 2*, Princeton University Press.

Tencer, Daniel (2016). Take A Number, Alberta Oilsands: U.S. Now Has World's Largest Oil Reserves, The Huffington Post Canada, Posted: 07/07/2016 4:47 pm EDT, Updated: 07/07/2016 5:59 pm EDT

Ward-Perkins, Bryon (2006). *The Fall of Rome: and the End of Civilization*. Oxford University Press, Oxford.