



Peak oil and the Fall of the Soviet Union: Lessons on the 20th Anniversary of the Collapse

Posted by [Luis de Sousa](#) on May 27, 2011 - 10:45am

This is a guest post by [Douglas B. Reynolds](#), Professor of Energy Economics at the University of Alaska, Fairbanks, Department of Economics, SOM

Synopsis: The causes of the fall of the Soviet Union are thought to be inefficiency and the Soviet response to the Reagan Administration's military buildup of the early 1980s. However, a more plausible explanation is the decline in Soviet oil production caused by peak oil. This gives the world an example of a modern economy confronted by peak oil and what lessons we can learn from it.

Neo-Classical Economics

In the West, we have great economic Nobel Laureates such as Hayek, Solow, Freidman, and Samuelson, who extol the virtues of markets for organizing an economy. Yet their theories for how great markets organize an economy contrast sharply with the planned economies of the Union of Socialist Soviet Republics (USSR) and the Soviet East. The odd thing is, the Soviet Union, even with a planned communist economy, managed to become a super-power with a military prowess that scared the West. Remember the Cuban missile crisis, or Khrushchev pounding the table at the United Nations with his shoe saying, "We will bury the West," or the Sputnik panic? Well, Kennedy (1987) shows quite profoundly that you can't have that degree of military prowess and be a world super-power unless you also have a strong and vibrant economy to back it up which, against all doctrines of conventional neo-classical economics, the Soviet Union had. It produced over 2 million motor vehicles a year, over 100 million tons of steel a year, and hundreds of advanced MIG jet fighters every year. So either the Nobel Laureates are wrong about their emphasis on markets or we don't have a correct picture of the Soviet Union and its economy at all.

However, we know that free markets do work, and upon close inspection, the Soviets actually did use markets: managers of communist enterprises had to engage in trades and internal political markets to obtain scarce resources for production; people created their own private little gardens, "dachas," that produced fruits and vegetables sold on farmers markets; workers were given bonuses as incentives to work hard; and the authorities allowed certain black markets to ease other Soviet planned inefficiencies. So in fact, the Soviet Union was market-oriented after all. Nobody has to give back their Nobel prizes just yet.

Still, Robert Solow (1956) suggests that technical progress is the cause of four-fifths of the US output per worker, which suggests that it should also cause four-fifths or so of increases in Soviet output per worker. However, neo-classical economists emphasize that free markets give the incentives necessary for such innovations, which makes you wonder why was the Soviet planned economy able to essentially keep up with America when it was not be able to give as many incentives as the US could and therefore could not induce innovations as well as the US could. One reason is that the Solow neo-classical growth theory is incomplete. Yes, labor, capital and

technological innovation are important inputs into economic growth, but what Cleveland et. al. (1984), Cleveland et. al. (2000), Smil (1991, 1994, 2005) and Reynolds (2002) make so clear is that energy is a vital ingredient to growth and technology. If you take away energy, the labor, the capital and the technology inputs cannot do a thing. As one physicist friend said to me once, "I bet (those economists) can't even change a tire."

So what all of the Nobel Laureates, the Nobel committee for the economics prize itself, and indeed, most economists are missing is the essential role of energy as an input into economic growth. Energy must be separated as an input into growth and analyzed and econometrically modeled. If that were done consistently, then energy analysis would be one of the most central themes in the American celebration of the global economic rise as well as a central theme in our understanding of the Soviet economy. The American and Western economies rose not just because of technology alone, but because of the use of high quality energy, and lots of it. Similarly, the Soviet Union rose due to energy use too.

The Importance of Energy for an Economic System

If we acknowledge that the Soviet Union had a powerful economy, which it did, and acknowledge that its economy was based on the same abundant, high quality energy that the US depended on, oil, then the reason for the fall is clear—peak oil. The fall of the Soviet Union is a peak oil event and if we treat it as such, then we can begin to understand what is in store for our own economy. Indeed, the fall of the Soviet Union is a perfect economic experiment for what will happen to our own world economy as peak oil continues.

According to *the Economist* (2010), the world is experiencing a rising cost for extracting energy because the energy needed to extract energy is rising, i.e. this is the concept of a falling Energy Return on Energy Investment (EROI). See Cleveland et. al. (1984), Hall et. al. (1986) and Hall (2008). What is more *the Economist* finally says what so many others, like Hamilton (1983), have been saying for years, that energy costs are affecting the economy. A decreasing EROI is in turn a general way to explain peak oil as it implies you can no longer find high EROI energy, e.g. conventional oil in large reservoirs but are instead finding low EROI oil, such as oil in small reservoirs. The decreasing EROI also implies another problem for the economy because the substitution away from high EROI oil is increasingly inelastic (Reynolds 1999c) and creates a loss of the Entropy Subsidy (Reynolds 1998). In other words, peak oil will cause economic decline. However, if peak oil is affecting the world, than why would it not have affected the Soviet Union too? Clearly it did.

No one has studied closely the Soviet Union's EROI to see, like our current world economies, if EROI was declining within the Soviet system and therefore affecting the Soviet economy. Nevertheless, one way to analyze the fall of the Soviet Union is to simply analyze its conventional oil use, which has been studied, see Reynolds and Kolodziej (2007 and 2008) and Reynolds (2009, 2001, and 1999a). Nevertheless, before we can look at a peak oil theory for the fall, it would be good to look at the alternative Soviet collapse theories that abound.

Alternative Soviet Collapse Theories

The *Economist* (2009), for its part, claims that it was a decline in total factor productivity (TFP) that may have caused the fall of the Soviet Union. However, upon a close inspection of Beare (2006) and Easterly and Fischer (1995), articles which surely would have been referred to in a TFP analysis, it is shown that in fact TFP was always growing, although at a declining rate, but growing nonetheless. Thus, a slow growth in TFP can only cause an economy to grow more slowly, not collapse. The upshot is that the Soviet TFP was not declining for 30 years as *the Economist* claims, but its rate of growth of TFP was declining. Still a poor TFP performance cannot have been the cause of the Soviet demise as even China had a poor TFP performance

Another hypothesis for the fall is the “Reagan Doctrine” hypothesis, where the US Presidential Administration of Ronald Reagan increased military spending and support of Soviet opposition in Poland and Afghanistan, which may have also caused the fall. But economists have yet to falsify that hypothesis although more than that, it doesn’t make sense. Reagan came into office after the USSR’s 11th Five Year Plan (1981) was already in place. With a Soviet Union as inefficient as it is said to have been, the Soviets would have needed time to react to Reagan’s military spending and then plan what to do. In fact, it would have been too difficult to start reacting to Reagan within the 11th Five Year plan without rewriting and reorganizing the whole plan, a feat that would have taken years. Better to change the 12th Five Year Plan starting in 1986) instead and begin to react against Reagan’s policies then.

However, the 12th Five Year Plan does not show any evidence of a huge change in defense spending, nor was there any recorded change in defense spending until about 1988, nor are there any other signs of change before then such as a radical increase in the number of missiles. That means the hypothesis, which depends on the idea that defense and internal communist police spending were taking away investment into new productive capital, would require many years after 1988 before an effect on the overall Soviet economy should have been observed, yet the fall started to happen in that very year of 1988 as that is when Eastern Europe, part of the Soviet Empire, started to have problems. Also, the propaganda surrounding the 12th Five Year Plan was one of openness (*glasnost*) and development (*uskorenıye*) not one of military spending increases or the need to more adequately defend the Soviet homeland. It seems highly unlikely that it was the 12th Five Year Plan that could have caused a precipitous fall in the Soviet Union that actually started in 1988 only two years after the beginning of the plan.

So what is needed is to take a different analytical tack in assessing the collapse of the Soviet Union, away from the political, economic and military propaganda, and consider the USSR as an energy system. Clearly it used the same high quality energy resources that the US and the rest of the world did, see Table 1, so that means that not only did the Soviet Union use some free market principles, parallel to the West, but it used almost the same energy systems as well. If we analyze the Soviet Union as an energy system therefore, rather than as a political or even economic system, then we can start to understand both its great economic output in spite of its inefficient planning and its great fall in spite of its internal (albeit black) market system.

Table 1. Conventional Energy Production			
Energy Source	USSR 1988	USA 1988	World 2010
Oil (million barrels per day, MBD)	12.5 MBD	9.7 MBD	85 MBD
Natural Gas (trillions of cubic feet per annum, TCFA)	27 TCFA	17 TCFA	137 TCFA
Coal	850 MTA	950 MTA	7240 MTA

(million tons per annum, MTA)			
Hydropower (gigawatts of installed capacity, GW)	64 GW	74GW	777 GW
Nuclear (gigawatts of installed capacity GW)	20 GW	100 GW	366 GW

The energy cost effects on the Soviet economy

To start with, it must be understood that as Reynolds (1994, 2002) points out, conventional crude oil is the most valuable of all energy resources, because it is a liquid (state grade). This is why for example oil sells currently for about €10 per Gigajoule (\$14/mmBtu) while coal sells for about €2 per gigajoule (\$3 per mmBtu). Also oil has 20,000 Btus per pound (weight grade), 1 million Btus per cubic foot (volume grade) and 500 billion Btus per acre in-situ (area grade). See also Smil's (1991) concept of power density. In aggregate, as a sort of energy theory of value, oil has the highest energy grade of any energy resource. It also has the highest energy return on investment (EROI) than any other energy when considering large conventional oil fields. See for example Hall (2008). So looking at the value of oil, it is clear why the Soviet Union rose to prominence as it was able to produce so much cheap oil upon which to base its economy. Oil smoothed out Soviet inefficiency. However, the Soviet Union fell when its oil production fell and it no longer had cheap, high quality energy.

In fact, isn't it the case that oil is the real reason that the US economy grew so rapidly during the early 20th century too, and then so slowly after 1973, the year of the first oil shock, as Cleveland et. al. (2000) show? Thus the Soviet Union and the US both had vast resources of oil and both grew powerful because they both exploited oil so much. Both economies extracted oil quickly, although the so called inefficient Soviet Union managed to exploit its oil resources even faster than the so called efficient USA: a 10% rate of growth in oil production for the USSR in its early years and a 7% rate of growth in oil production for America in its early years. However, both the Soviet Union and America saw peaks in their oil production, the US in 1970, as M. King Hubbert (1956) and *many others* (see Brandt 2010) predicted; the Soviet Union in 1988. See Figures 1 and 2. Thus the US shows that no matter how advanced or efficient an economy is—and the US is one of the best—you will eventually endure peak oil, and that an oil shock caused by oil scarcity can affect your economy adversely.

Figure 1. Former Soviet Union Oil Production as a Function of Cumulative Production



Figure 1

Figure 2. US Lower 48 and Alaskan Oil Production as a Function of Cumulative Production

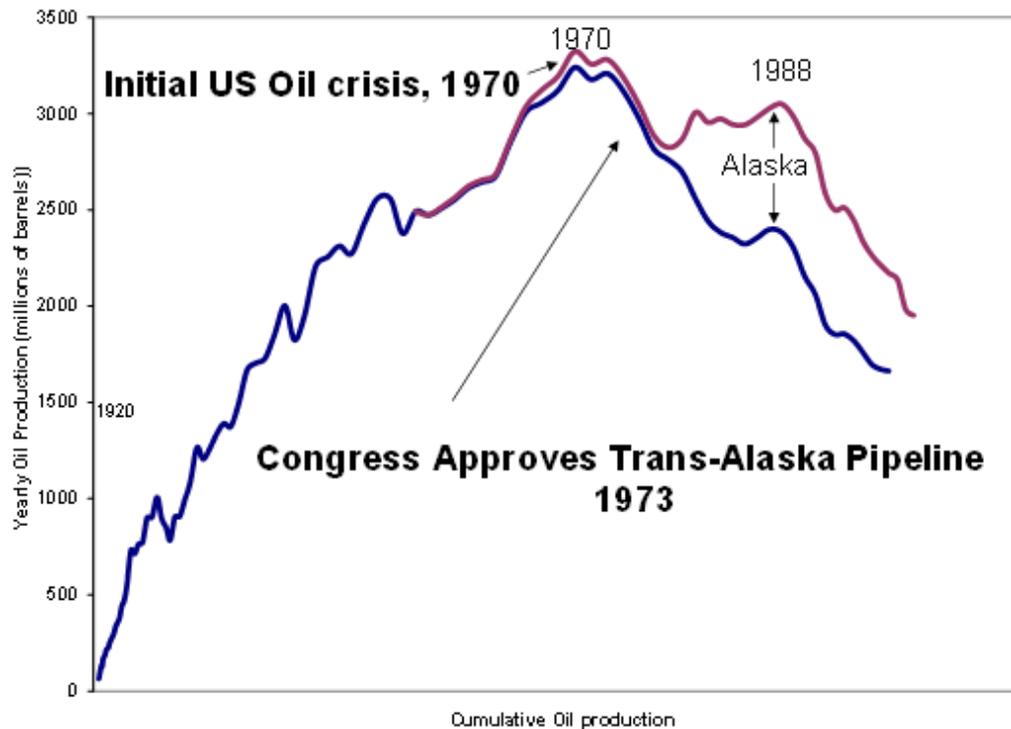


Figure 2

The Chicken or the Egg?

Being a closed economic system, the USSR and the Soviet East had very little trade with the West and so that system had to depend completely on its own oil production. When Soviet oil production declined, so did its economy. You could argue that a lack of markets, Soviet inefficiency or the political chaos in the 1980s caused the production to fall, but as spelled out in

Reynolds (2000) and Reynolds and Kolodziej (2007, 2008) the only thing that makes sense is that scarcity caused the decline in oil production first and that the decline in oil production caused the collapse of the Soviet East afterward. After all, why did only Soviet oil production decline but not Soviet natural gas production, two industries that are very similar, if inefficiency was so rampant? Why did Soviet oil production increase before 1980 without much Western technology only to suddenly start declining after 1980 even when the Soviets had access to Western technology? And why did a period of glasnost cause the Soviet Union and the Soviet oil dependent Eastern Europe to collapse, but a similar glasnost caused China to rise and stay communist? The only explanation that works is the dependency on internal cheap oil and the peak oil hypothesis.

If you look closely at the news prior to the collapse of the Soviet Union, you see that first Eastern Europe went through economic chaos starting in 1988, the year of Soviet peak oil, followed by Russia in 1990 and beyond. Interestingly, once the Soviets saw their peak in oil in 1988, they forced all the Council of Mutual Economic Assistance (CMEA) countries to pay for their Russian derived oil in hard currency and at Western oil prices. But the Eastern European countries had no such currency to pay for oil and so they had to curtail their use of oil. Well, without any (almost free) oil available, you cannot run a modern economy no matter how efficient it is let alone an inefficient communist one. This caused the Eastern European economies to collapse and revolutions in Eastern Europe to erupt starting in 1988. Basically there were about 20 “French Revolutions” in the span of four years as communist government after communist government fell.

Clearly, then 1988 is the initial point of the overarching fall of the Soviet Union when you include its regional influence in Eastern Europe. But as Soviet oil production continued to decline after 1988, peak oil affected the Soviet economy as well, causing its collapse. The Soviets eventually endured their first stagflationary shock in October of 1989 when their currency was devalued by 90%. Eventually, as the Soviet economy fell each of the Soviet Republics from Lithuania to Kazakstan left the Union. And during that whole time Soviet and post-Soviet oil production fell from a high of about 12 million barrels of oil produced per day to a low of about 7 million barrels a day, a 40% decline. So the real reason for the fall of the Soviet Union was an oil crisis. It was the third major oil crisis of the 20th century after the 1973 and 1979 oil crises, but you never hear of it.

The Post-Soviet Oil Rise

You might ask, if there was peak oil in the Soviet Union during the fall, then why did former Soviet oil production rise again after 1996? Doesn't this mean that there was plenty of oil and that it was their own inefficiency that caused the collapse in oil production? To answer this question consider a parallel question. Why did the ancient Babylonians of Mesopotamia fall? After all, if the ancient Babylonians had modern 21st century technology, they would not have fallen. Well, they did not have that technology, but then neither did the Soviets have a lot of Western technology, not because the Soviets did not buy much new oil technology from the West, but because their system was not set up to use that technology.

The main reason for the rise in Post-Soviet oil production was that there was a change in relative prices between energy and labor, a change in property rights and a change in the over-arching market structure behind the use of such technology. See Dienes (2004) for the complete analysis. During the Soviet era, the oil production enterprises used simple primary and secondary oil production techniques to produce the massive oil that existed. However, the enterprises depended on Soviet technology, Soviet supply lines and above all were under Soviet government dictums. This is where we must also use conventional neo-classical economics to understand events. Remember, oil was basically given away at a low cost, but there was an initial government plan and investment to get it, i.e. a cost within the planned economic structure. Nevertheless, there was little incentive within the system to upgrade the necessary technology and invest

heavily in new techniques because the price was set so low, although much investment did occur within the confines of the system.

The one thing that Soviet oil enterprises could not do was to manage the oil resources to maximize the value of oil over the long term. Better to produce quickly now, and ruin a field or waste oil, than to produce more slowly to maximize total value. Nevertheless, such waste does not imply a lack of technology caused the fall, it implies a lack of oil caused the fall and that the lack of technical efficiency did not help matters. After all, if the Soviets had had ten more Western Siberias of oil, or even 100 more, then their oil production would not have fallen—they would not have had peak oil—because more cheap oil would have been available. Still whether you have an efficient car or an inefficient car, it cannot run without any fuel.

After the fall, once property rights changed, and the price of oil relative to other economic inputs, especially labor, was raised, it was relatively easy not just to bring in massive amounts of new technology to reinvigorate ruined fields, but also it was easy to manage the pace of production to maximize the fields' long term value. Nevertheless, the fact remains that under a closed and bureaucratic system that was unable to change, oil became scarce *within the confines of that system*. Indeed oil production declined in America's own oil sector under America's so called advanced market based system. Thus, with a closed and relatively less efficient system, it could not have been lower levels of technology, lower levels of investment and lower levels of management that caused a Soviet peak and decline in oil since Soviet technology and management—though inefficient—was always improving. Rather it was oil scarcity, i.e. the lack of more large oil fields available, that caused the oil production decline. Indeed, Soviet investments into the oil sector were increasing as Gustafson (1989) makes clear. More investment, better technology, and more openness toward the end of the Soviet Union cannot cause a peak oil event, only scarcity can do that.

Will the World Follow a Soviet Style Peak?

The Soviet Union endured a peak in oil production within its particular system. Once the system changed, there was indeed a renewal of oil production, but even under the new system today there is again peak oil as figure 1 shows. However, just because a system can change, does not mean that the old system did not endure peak oil, it did. Logic dictates cause and effect in time and context. Thus while the Soviet Union's region does not change from 1988 to 2010, its economic system did. Still, even if a more efficient system was put in place in that region and caused oil production to increase, that still does not imply that the fall of the Soviet Union was not caused by peak oil.

The crux of the issue is, can the world also endure the same oil crisis event that the Soviet East endured? Yes it can. Seeing as the world is a closed system with a certain level of technology then it too is subject to peak oil and the economic consequences of that peak. We will surely endure the same crisis that the Soviet's endured and indeed we already are, as the *Economist* (2010) tacitly, though unknowingly, admits. See Figure 3 to view where peak oil stands for the world.

Figure 3 Forecasted Trend and Actual Production for World Crude Oil

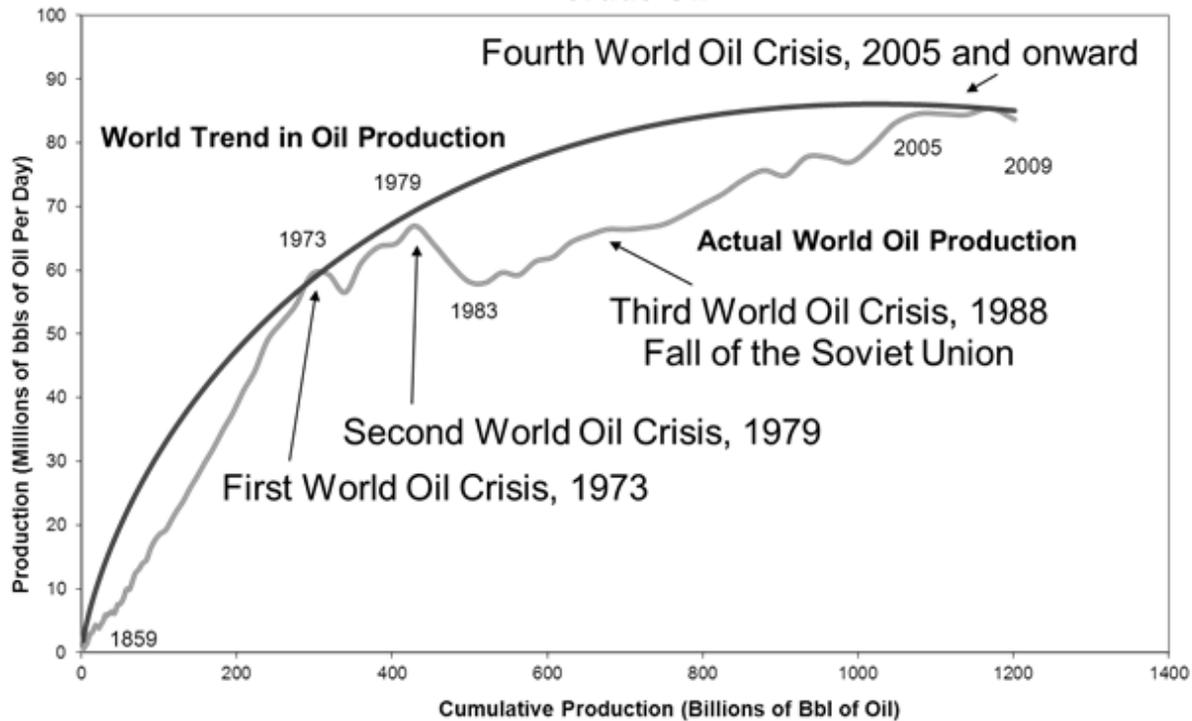


Figure 3

Many of those who look at peak oil consider the world's peak oil, as shown in Reynolds (1999b and 2009), to be a short run phenomenon and that, rather like the Soviet Union, oil production will soon increase again possibly because of the Iraqis newly revitalized oil sector. However, a close comparison of the Soviet Union and the world suggests that the world will not suddenly have an increase in oil production as the Soviet Union did. Consider these points: First the Soviet Union had a huge increase in technology after 1996 and especially after its currency crisis in 1998. Second the whole of the region of the Soviet Union, not just one little oblast, was changed. Finally, most of the Soviet oil reserves shifted from state ownership to being privately held. If we were to compare the world to the Soviet Union, none of these conditions are present, and therefore the world in total cannot possibly have a new round of oil production increases the way the post Soviet Union did.

However, all of the oil producing countries of the world currently have the latest and greatest oil production technologies and access to any and all innovations. So unlike the Soviet Union, there can be no technological revolution for the world. Next, the world already has relatively free markets even in Russia and the Middle Eastern countries. These free markets allow capital and labor to move relatively easily and quickly to wherever they are needed, and so an increase in free markets is not possible, they already exist. Finally, as far as property rights are concerned, most oil producing countries are not about to turn over their vast oil reservoirs to private control as the former Soviet Union did. State ownership for most oil reservoirs will continue, and so a Soviet style increase in oil production for the entire world should not be expected.

Thus in order for the world to increase its oil production on the same magnitude and relative scale as the former Soviets managed, you would need a worldwide revolution in technology, institutions and markets, not just a change in one relatively small oil producer of Iraq, and that is just not going to happen.

The Soviet Union's Peak Oil as an Economic Experiment

What so many Sovietologists and economists fail to consider about the Soviet Union is that the Soviets knew about peak oil, seeing as they had one of the most technically well-educated workforces in the world with top mathematicians, physicists and oil geologists. Indeed, the Soviets were actively trying to find solutions for peak oil with new energy technology. The Soviets clearly researched alternative energy technology previous to the fall, such as solar energy, oil shale energy and nuclear power, (CIA 1985). Those same top people undoubtedly warned the Soviet brass about the problem of peak oil and there was indeed a tremendous increase in energy research and oil investment in the USSR. This bodes badly for our own predicament, for even though we have also conducted much alternative energy research and oil investment, the Soviets, and our own 1970's energy investments show that alternative energy has never been able to help an oil crisis.

So knowing the world rate of oil production has already peaked, then what can we expect? The Soviet Union's collapse offers a preview. We can expect a great stagflation, where you simultaneously see a declining economy and hyperinflation. We can expect to see high unemployment and a collapse in the world economy. We can expect to see governments without any money to pay for things like health care, pensions, environmental problems, prisons, education or defense. We can expect to see infrastructure decay. We can even expect to see a decline in population. Finally, similar to the post Soviet Union, we can expect to see protests, political turmoil and revolution.

The Origins of the Financial Crisis is from the Oil Crises of the Past

So, what the Soviet Union endured is exactly what we are seeing now. Indeed, the entire financial crisis and its own resulting political turmoil is not about finance at all, but about peak oil. If you go back to the US administration of Ronald Reagan and even before, the so called free market economic revolution that he inspired was really only a set of policies in reaction to the oil crises of the 1970s. To some degree these policies worked, such as deregulating airlines, but to some degree these policies did not work such as deregulating banks. This culminated in the 1990s with the Dot Com bubble and the currency crises of Asia and the developing world, and continued in the early 2000s with government policies to help the housing and construction industries grow beyond sensible levels. However the culmination of the housing bubble occurred when all these people living on the edge of their limited weekly pay, could not simultaneously pay for gasoline, due to high oil prices, and their mortgages and had to choose to foreclose. Now that these bubbles have burst, there is nowhere left to hide. No more growth is possible without more cheap energy.

As the Nobel Laureates explain, a free market system is about the best system available for society, but that does not mean free markets are powerful enough to overcome peak oil. Maybe economics needs a bit of engineering reality thrown in, but to be fair, many engineers, business people, physicists, biologists and so on, also believe in the power of technology. By studying the economic events surrounding the fall of the Soviet Union, we can at least be better prepared to handle the consequences of our inevitable collapse. A full understanding of the economics of energy such as the EROI, energy grades, peak oil and the Hubbert curve, will help, although now it's a bit too little, too late. We just have to learn from the former Soviets and just handle each crisis as it occurs.

REFERENCES

Beare, Bredan K. (2008). "The Soviet Economic Decline Revisited," *Econ Journal Watch*, Volume 5, Number 2, May 2008, pp 135-144.

Brandt, Adam R. (2010). "Review of mathematical models of future oil supply: Historical overview and synthesizing critique," *Energy*, 35, pp. 3958 – 3974.

Dienes, L. (2004). Observations on the Problematic Potential of Russian Oil and the Complexities of Siberia. *Eurasian Geography and Economics*, 45, No. 5, pp. 319-345.

Central Intelligence Agency (1985). *USSR Energy Atlas*. CIA, January. US Government Printing Office, Washington D.C., Stock Number 041-015-00157-4, pp. 22, 36.

Cleveland, Cutler; Robert Costanza, Charles A. S. Hall, Robert Kaufmann (1984). "Energy and the US Economy, A Biospheric Perspective." *Science*, Volume 225, number 4665, August 31, pp. 890-897.

Cleveland, Cutler; Robert Costanza, Charles A. S. Hall, Robert Kaufmann (2000). "Aggregation and the Role of Energy in the Economy." *Ecological Economics*, Volume 32, pp. 301-317.

Easterly, William and Stanley Fischer (1995). "The Soviet Economic Decline," *The World Economic Bank Review*, volume 8, number 3, pp. 341-371.

The Economist, (2010) "Engine Trouble: a rise in the cost of extracting energy will hit productivity," Buttonwood, October 21, 2010.

The Economist, (2009) "Secret sauce: China's rapid growth is due not just to heavy investment, but also to the world's fastest productivity gains," Economics focus, Nov 12th 2009.

Gustafson, Thane (1989). *Crisis Amidst Plenty: The Politics of Soviet Energy under Brezhnev and Gorbachev*, Princeton University Press, Princeton, NJ.

Hall, Charles A. S., Cutler J. Cleveland, and Robert Kaufmann (1986). *Energy and Resource Quality: The Ecology of the Economic Process*, Publisher: University Press of Colorado; Reprint edition (February 1992).

Hall, Charles A. S. (2008). *EROI on the Web, Part 1-6*, The Oil Drum.com, 1) Why EROI Matters, <http://www.theoilcrisis.com/node/3786>, 2) Natural Gas and Imported Oil, <http://www.theoilcrisis.com/node/3810> 3) Tar Sands and Oil Sands, <http://www.theoilcrisis.com/node/3839> 4) Nuclear Power, <http://www.theoilcrisis.com/node/3877> 5) Passive Solar, Photovoltaic, wind and hydroelectricity, <http://www.theoilcrisis.com/node/3910> 6) Wind, Geothermal <http://www.theoilcrisis.com/node/3949>.

Hamilton, James D, (1983). " Oil and the macroeconomy since World War II," *Journal of Political Economy*, University of Chicago Press, vol. 91(2), pages 228-248, April.

Hamilton, James D, (2009). "Causes and Consequences of the Oil Shock of 2007-08," Brookings Papers on Economic Activity, 2009, muse.jhu.edu.

Hubbert, M.K. (1956). "Nuclear energy and fossil fuels," *American Petroleum Institute Drilling and Production Practice Proceedings*, proceedings in 1956, published in Spring 1957, pp. 7-25.

Homer-Dixon, Thomas (2006). "The End of Ingenuity," OP-ED CONTRIBUTOR, New York Times, Published: November 29, 2006

Reynolds, Douglas B., (2009) Chapter 1, OIL SUPPLY DYNAMICS: HUBBERT, RISK AND INSTITUTIONS In: OPEC, Oil Prices and LNG, Editor: Edward R. Pitt and Christopher N. Leung, ISBN:978-1-60692-897-4, ©2009 Nova Science Publishers, Inc.

_____, (2002) *Scarcity and Growth Considering Oil and Energy: An Alternative Neo-Classical View*, The Edwin Mellen Press, 240 pages.

_____, (2001) "Oil Exploration Game with Incomplete Information: An Experimental Study," *Energy Sources*, Volume 23, Number 6, July, pp. 571-578.

_____, (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.

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

_____, (1999b). "Oil Scarcity Should Be a Concern," *USAE Dialogue*, Volume 7, number 1, pp. 12-13, a part of the IAEE association.

_____, (1999c) "Entropy and Diminishing Elasticity of Substitution," *Resources Policy*, March, Volume 25, Number 1, pp. 51 – 58, 25th Anniversary Volume

_____, (1998) "Entropy Subsidies," *Energy Policy*, February, Volume 26, Number 2, pp. 113-118.

_____, (1994) "Energy Grades and Economic Growth," *Journal of Energy and Development*, Volume 19, Number 2, Spring 1994, pp. 245 – 264.

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 Marek Kolodziej. (2007) "Institutions and The Supply of Oil: A Case Study of Russia" *Energy Policy*, Volume 35, pp. 939 – 949.

Reynolds, Douglas B., Jacob Joseph, and Reuben Sherwood (2009). "Risky Shift versus Cautious Shift: Determining differences in risk taking between private and public management decision-making," in *The Journal of Business & Economics Research*, January 2009, volume 7 number 1.

Solow, Robert M. (1956). "A Contribution to the Theory of Economic Growth," *The Quarterly Journal of Economics*, Vol. 70, No. 1. (Feb., 1956), pp. 65-94.

Smil, Vaclav (2005). *Energy at the Crossroads Global Perspectives and Uncertainties*. The MIT Press, Cambridge, MA, xiv + 427 pp. Revised and updated paperback edition.

_____(1994). *Energy in World History*. Westview Press, Boulder.

_____(1991). *General Energetics: Energy in the Biosphere and Civilization*. John Wiley, New York, xiii + 369 pp.



This work is licensed under a [Creative Commons Attribution-Share Alike 3.0 United States License](http://creativecommons.org/licenses/by-sa/3.0/).