Economics from the Top Down

new ideas in economics and the social sciences

US Oil-and-Gas Production: Signs of an Impending Bust

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When it comes to the exploitation of non-renewable resources, what's up for debate is not *if* the rate of harvest will peak and decline, but *when* this peak will occur.

Here, some recent history seems relevant. Back in the mid 2000s, peak-oil theorists stridently predicted that world oil production would soon peak. In hindsight, these folks were wrong … but not entirely so. The production of *conventional* oil peaked in 2005, more-or-less as predicted. However, *total* oil production did not peak, largely because the production of non-conventional oil exploded. Since this non-conventional oil more than made up for the decline of conventional oil production, talk of 'peak oil' basically died.

From this episode, there is a wrong lesson and a right lesson to be learned. The wrong lesson is that oil is so abundant that its exhaustion is nothing to worry about. The right lesson is that oil production *will* peak, but the timing is difficult to predict, because it depends on technological and social factors that early peak-oil theorists failed to appreciate.

Because the United States is at the epicenter for the growth of non-conventional oil production, it seems useful to use it as a case study. While the timing of the second peak of US oil production remains uncertain, there are signs that all is not well in the US oil patch. Let's have a look.

The US shale boom

In the late 2000s, peak-oil thinkers were predicting an imminent catastrophe. For example, in his 2008 book, *World Made by Hand*, James Howard Kunstler imagined an America 'a few decades hence', in which the terminal decline of oil production was ravaging industrial civilization. According to the back cover, the novel is a tale of "love and loss, violence and power, sex and drugs, depression and desperation". In some sense, Kunstler anticipated the hellscape that is today's US politics ... but the reasons for this hellish scene have nothing to do with peak oil.[1]

As Figure 1 shows, shortly after Kunstler's books was published (in 2008), the US oil-and-gas industry experienced a remarkable reversal of fortune. For decades prior, the US oil business had been the poster child for peak oil, with production peaking in 1970 and declining inexorably thereafter. But in the 2010s, the fracking revolution brought a bonanza of new resources online. Today, US oil-and-gas production has far surpassed its 1970 peak.

Natural gas is king

While it may be peak 'oil' that is infamous, these days peak *gas* is arguably more important. The backstory is that for over a century, natural gas has been slowly replacing oil as the dominant fossil fuel powering industrial society. Figure 2 shows the transformation in the United States.

During the early years of the 20th century, the internal-combustion engine made oil the king fossil fuel. Oil dominance (relative to natural gas) peaked in the early 1920s, around the time the production of the Ford Model T reached an all-time high. From then on, natural gas gradually become the more important fuel.

The rise of natural gas dominance came in two waves. During the first wave, which began after World War II, natural gas became the dominant fuel for home heating. During the second wave, which took off during the 1990s, natural gas became the dominant fuel for generating electricity.

Figure 3 illustrates the transition to gas-generated electricity, which was driven by several factors. First, natural gas is cheap and easy to transport (via pipelines). Second, when gas is burned in a combined-cycle power plant,

[1] Ironically, since the peak of his peak-oil popularity, Kunstler has transformed himself into a far-right ideologue, thereby contributing to US social dysfunction.

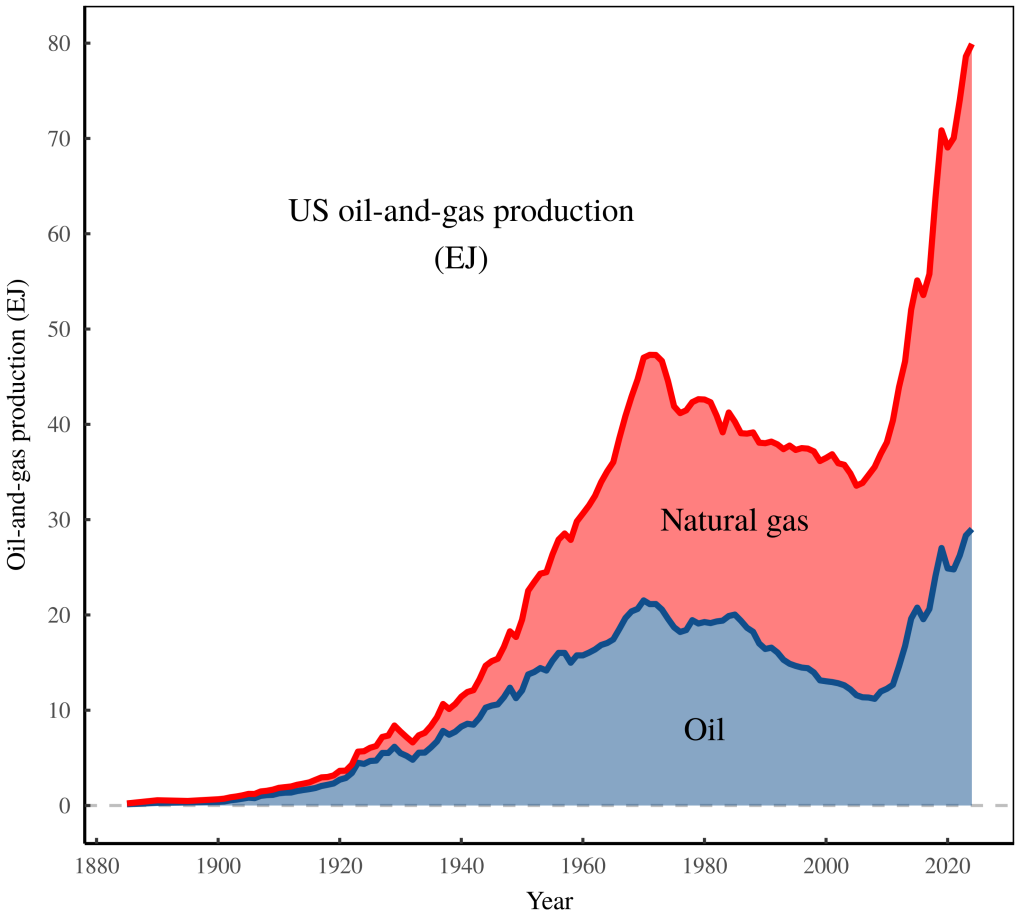

Figure 1: The history of US oil-and-gas production

US oil-and-gas production peaked in 1970 and then began what many analysts regarded as a terminal decline. However, in the 2010s, the shale revolution led to an unprecedented rise of oil-and-gas production. Sources and methods

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it is by far the most efficient method for generating thermo-electric power. (As always, efficiency drives consumption.) Third, environmental concerns led many utility companies to retrofit coal plants to run on gas. So yes, coal has been phased out in many jurisdictions, but only because gas offers a drop-in replacement.

Notably, demand for electricity has surged in the last decade, largely because of the push to electrify transportation. Since coal and nuclear energy are both off the table (for social/environmental reasons), and renewable energy is not yet up to the task of meeting rising demand, natural gas has filled the gap.

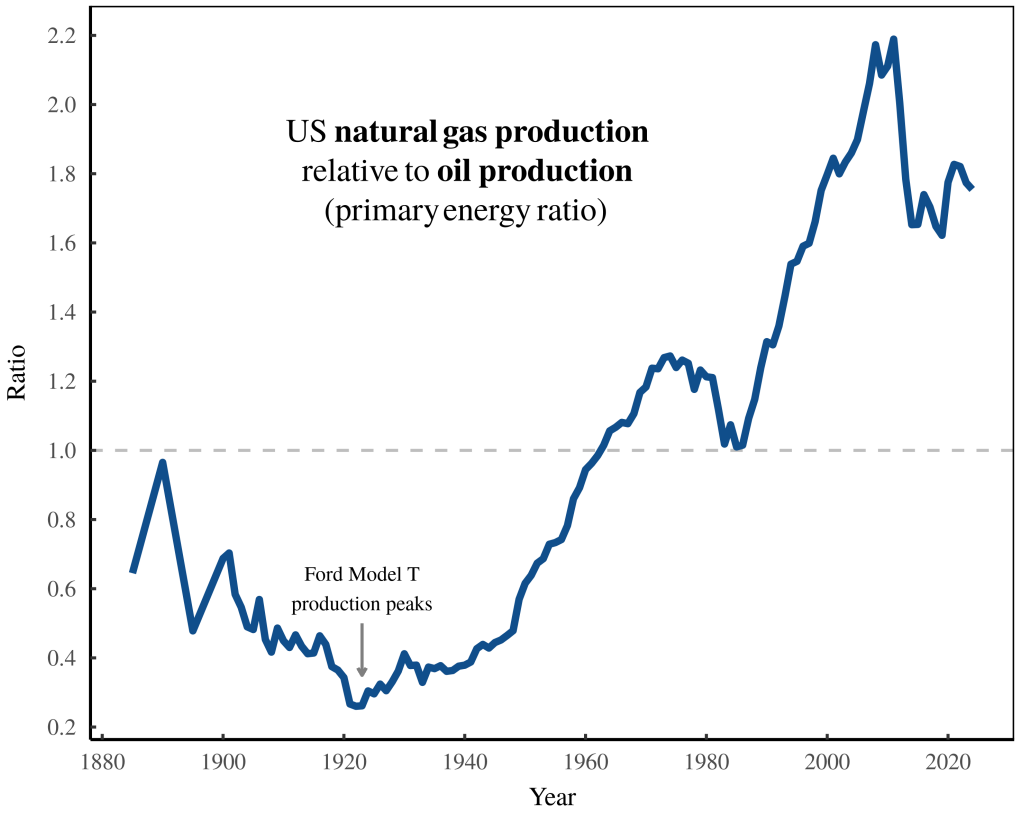

Figure 2: The natural gas transition

The blue curve plots the ratio of US natural gas production relative to US oil production, measured in units of primary energy. Sources and methods

Looking to the future, it's fine to use natural gas as a stop-gap to fuel the transition to electric transportation. But the risk is that gas production begins to decline before the renewable build-out can power the grid. (The other risk is that we ramp up electricity consumption for stupid purposes, like filling the internet with AI slop.)

Beneath the US shale boom, pessimistic signs

Back to US oil and gas. While production may be at an all-time high, worries about the future are surfacing. Here's a sample of the anxiety in 2025:

- "The heart of the US oil boom is slowing" (Reuters)
- "Oil chiefs warn of end to US shale boom" (Financial Times)
- "Energy slowdown … is well underway" (Fortune)

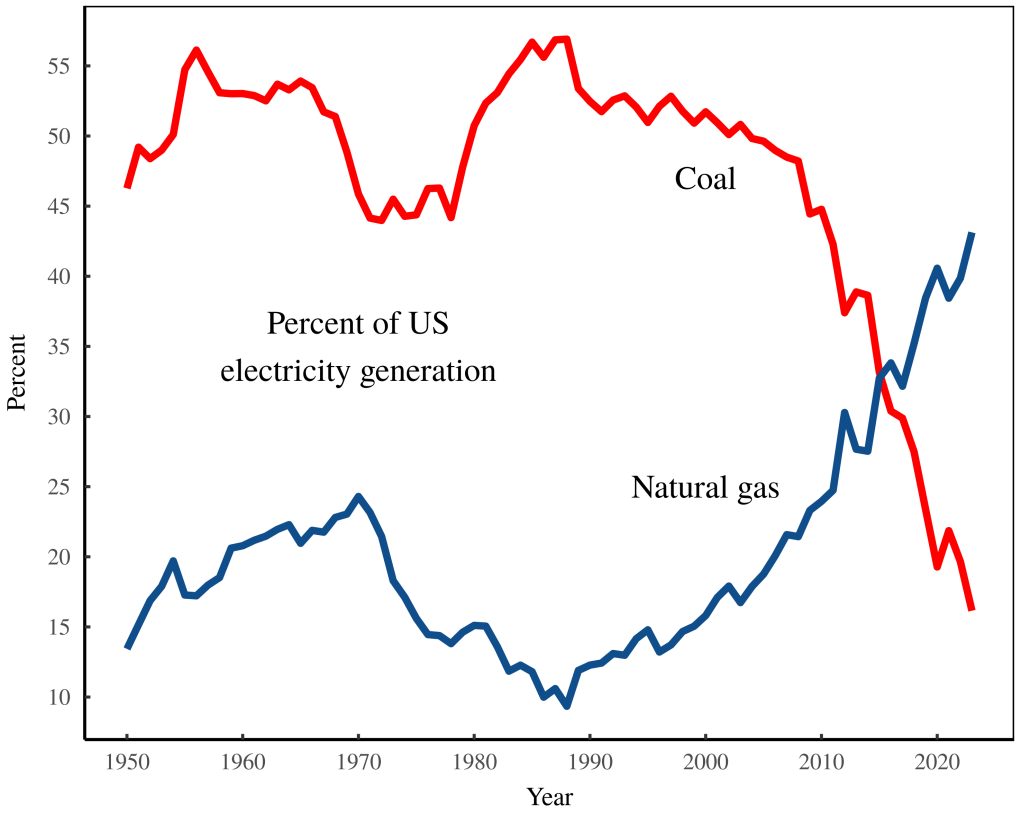

Figure 3: The gas-powered electric grid

In the United States, natural gas is now the dominant fossil fuel for generating electricity, largely because it has replaced coal-powered generation. Sources and methods

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- "US oil production to peak by 2027 as shale boom fades, EIA forecasts" (Business World)

Now aside from the EIA forecast about an impending peak, most of this worry was driven by fears about the business model of shale oil production. In my view, folks are right to fret about this business viability. Which brings me to some historical problems with peak-oil theory.

The theory became famous after the geologist M. King Hubbert correctly predicted the peak of US oil production, circa 1970. To make this prediction, Hubbert's method was quite simple. First, he estimated the US oil reserves that would ultimately be recovered. Then he assumed that production would follow a bell curve. From there, it followed that US oil production would peak in the early 1970s . . . which it did. For many years after, as US oil production continued to decline, it looked like Hubbert would have the last laugh. But then the shale revolution blew a hole through Hubbert's thinking.

In hindsight, there are two main problems with Hubbert's simple approach to peak oil. First, the quantity of oil that humans will eventually recover depends not just on geophysics, but also on our technology and social structure. (New technology can expand the pool of exploitable reserves. And technological decline could decrease the pool of exploitable reserves.) Second, the exploitation of oil need not follow a bell curve; technological and social shocks can lead to bumpy harvest patterns that are difficult to predict.

Of course, this is not to say that the general features of Hubbert's thinking were wrong: oil is finite and non-renewable, which means its exploitation cannot and will not last forever. But the lesson from recent history is that predicting the peak of oil production is more difficult than early theorists let on.[2] So rather than make grand claims about the second peak of US oil-and-gas production, a better approach is to watch the changing dynamics of the oil industry itself.

A good place to start is with the dynamics of drilling. In this regard, the oil industry has an exceptionally simple business model: it drills holes in the ground and sells the stuff that comes out. In other words, without perpetually drilling more wells, the oil industry will quickly go bust.

Here, it's worth noting that the US shale revolution is *not* based on a boom in drilling. Instead, the secret to the shale revolution lies in new techniques for sucking more oil and gas out of each individual well. (The trick is to drill horizontally through the formation, and then hydraulically fracture the reservoir so that the resource flows more easily.)

Unfortunately, a moments thought shows that this productivity trick likely has a short shelf life. It works only if there are huge, untapped reserves on hand. But once horizontal drilling starts to drain these big reserves, the dynamics of marginal decline inevitably set in. As the big reserves are sucked dry, oil companies have no choice but to drill fresh wells in less fertile terrain. To the extent that this search becomes unprofitable, oil companies will slow their drilling.

It's here that we see signs of impending trouble in the US oil business. While oil-and-gas *production* is at an all time high, oil-and-gas *drilling* is now in decline. Figure 4 shows the pattern. After nearly a century of growth, US drilling peaked in the late 1970s. Paradoxically, the shale revolution of the 2010s came with a pronounced drilling *downturn*. If this downturn continues,

[2] In his book *The Economic Superorganism*, Carey King offers a detailed critique of the geology-only approach to peak oil. See my review of his book here.

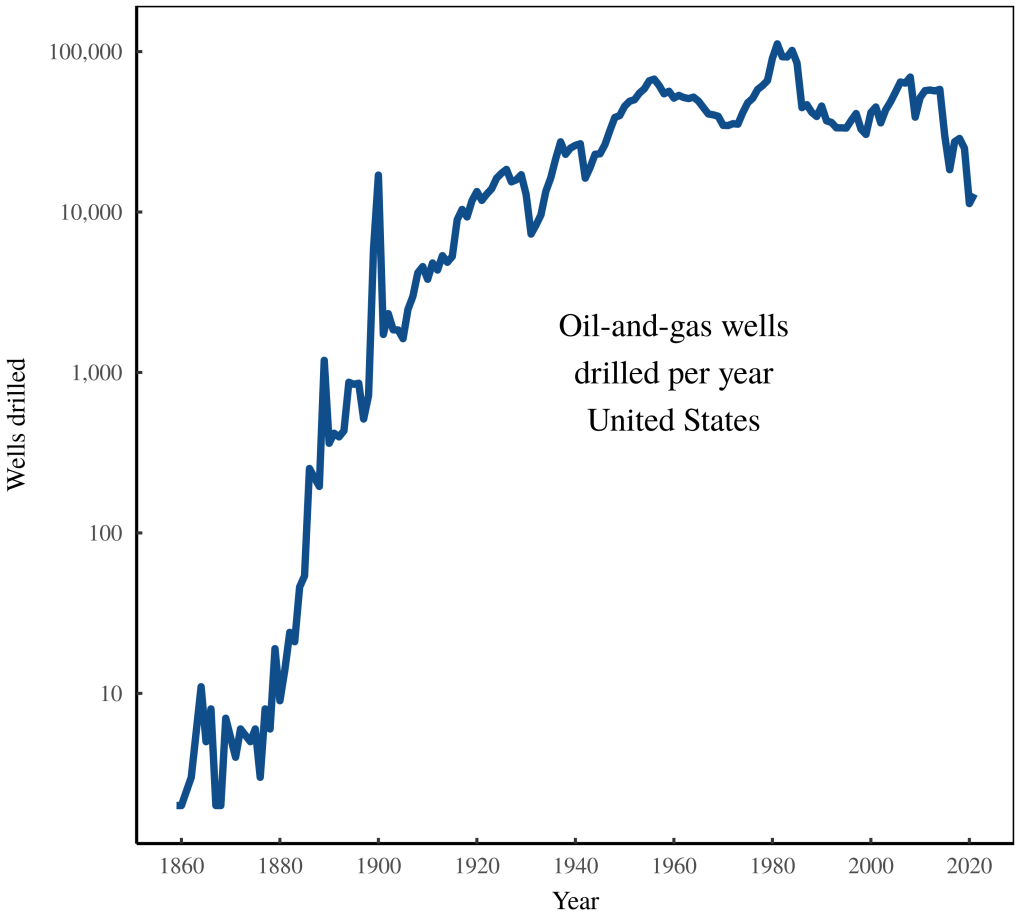

Figure 4: US oil-and-gas wells drilled per year

The data covers the years 1859 to 2021. Note the log scale on the vertical axis. Sources and methods

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then a second peak of US oil-and-gas production is surely imminent. Absent the perpetually rising productivity of individual wells (which is a pipe dream), a continuous drop in drilling spells the death of the shale revolution.

U-shaped economics

Since the oil-and-gas business is notoriously volatile, we should be cautious about reading too much into the recent decline in US drilling. If the price of oil were to explode, we'd surely see another drilling boom. That said, there are long-term forces at play that are largely independent of the oil business' short-term volatility.

Perhaps the most basic force is the relative affordability of drilling for oil. This affordability is important, because it sets the lower bound on the price of oil. If drilling is cheap, then oil can be sold cheaply for a profit. But if drilling is expensive, turning a profit requires that oil be expensive.

Now, over the long term, we can predict that the cost of oil drilling will have a U shape (when measured relative to income per capita). In the early stages of exploitation, oil extraction is labor intensive, and hence, expensive. But as technology improves, the price of drilling drops precipitously. Eventually, however, the physics of natural resource exhaustion intervene. With the easy-to-access resources gone, oil companies start drilling in more inaccessible places. As that happens, the cost of drilling begins to rise.

Looking at the United States, the country now sits on the second half of this U-shaped curve. Figure 5 runs the numbers. Here I've plotted the average cost per US oil-and-gas well, pegged against US income per capita. (Caveat: the red portion of the curve uses a proxy for well cost, so take this data with a grain of salt.) Historically, it seems that drilling for oil was most affordable in the late 1980s. Today, U-shaped costs have made drilling more expensive. Relative to US income, drilling an oil well now costs roughly the same as it did in the late 19th century. Cause for petroleum euphoria, this is not.

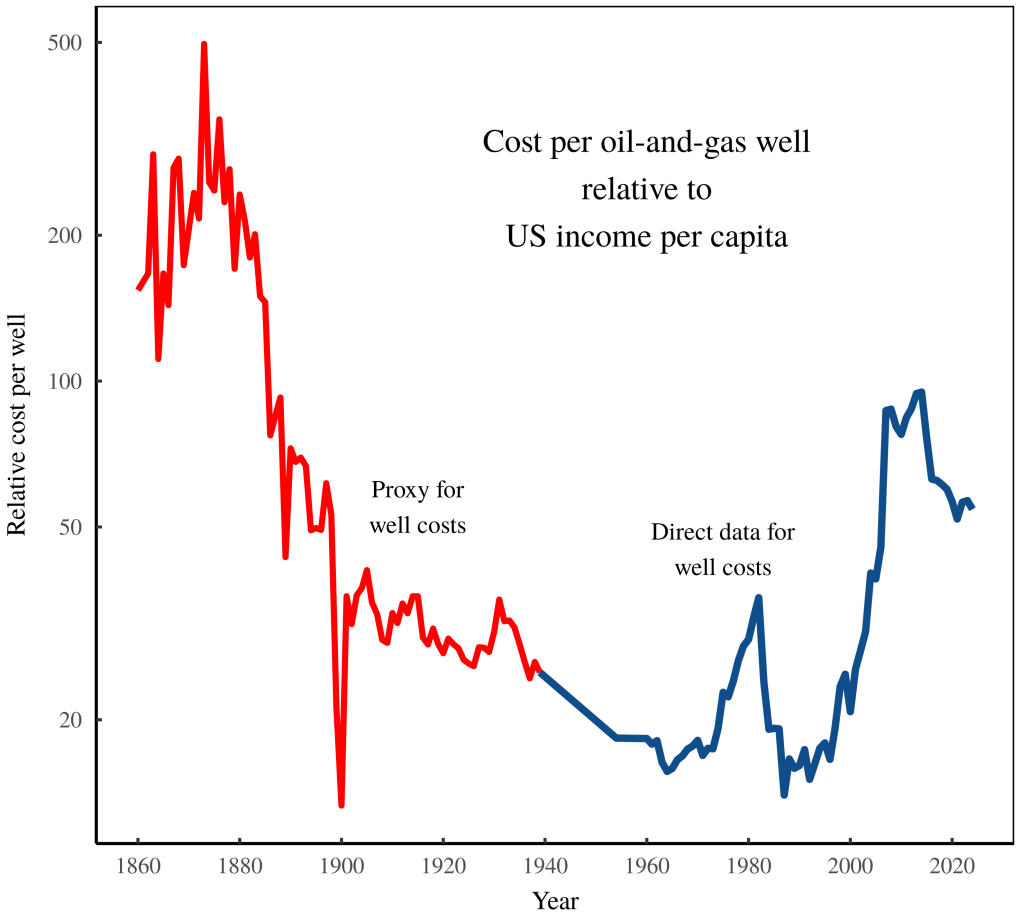

Figure 5: Average cost of US oil-and-gas wells relative to US income

Simple reasoning suggests that when pegged against income, the cost per oil-and-gas well should have a U shape. In other words, drilling should be initially expensive, but get cheaper as technology improves. Then, as the easy-to-tap reserves are exhausted, drilling should become more expensive. Based on the data shown here, it seems that the US is now firmly in the second part of the well-cost 'U'. Note that the red portion of the curve uses a proxy for well costs, so treat it with appropriate uncertainty. Also note the log scale on the vertical axis. Sources and methods

All the oil . . . and all the dysfunction

Today, we are nearly twenty years on from the peak of peak-oil worries. It's therefore instructive to reflect on how things panned out.

What's remarkable is that in the United States, much of the social dysfunction that peak-oil theorists predicted *has* come to pass . . . but within a landscape of remarkable US oil *abundance*. It goes to show that while fossil-fuel scarcity may be a key problem for the long-term future of industrial society, it's far from being the only driver of social chaos.

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Sources and methods

US oil and gas production (Figures 1 and 2)

Data is from the following sources:

- 1949 to 2024: US Energy Information Agency, Table 1.2, Primary energy production by source;
- 1885 to 1948: Historical Statistics of the United States, series Db157 and Db158.

US electricity mix (Figure 3)

Data is from the US Energy Information Agency, Electricity in the United States.

US oil-and-gas drilling (Figure 4)

Data for annual drill counts is from the United States Geological Survey, Aggregated Oil and Natural Gas Drilling and Production History of the United States.

Well costs relative to US income per capita (Figure 5)

Direct measures of relative well costs (1939 to present) use the following data:

- Nominal cost per well:
  - 2008 to present: FRED, producer price index for drilling oil-and-gas wells, series PCU213111213111. I index this price-index data to EIA well-cost data in 2007;
  - 1960 to 2007: Energy Information Agency, Costs of crude oil and natural gas wells drilled (I use nominal price data);
  - 1939 and 1954: data is from the 1939 and 1954 Census of Mineral Industries.
- To calculate relative costs, I divide the nominal cost per well by US income per capita, using the following data:
  - 1947 to present: US nominal GDP per capita from FRED series A939RC0Q052SBEA;
  - 1860 to 1946: GDP per capita using data from Historical Statistics of the United States, GDP series Ca10, population series Aa6;

Proxy measurements of well costs (used prior to 1939) are calculated as follows. First, I calculate the number of oil-and-gas workers employed per well drilled:

- Well-count data is from the United States Geological Survey, Aggregated Oil and Natural Gas Drilling and Production History of the United States.
- Data for oil-and-gas employment is from the following sources:
  - 1929 to present: US Bureau of Economic Analysis, Tables 6.8A–D, Persons Engaged in Production by Industry, archived at Econostats;
  - 1860 to 1928: Historical Statistics of the United States, Colonial Times to 1970, Table M5-6;

Next, I calculate the log-log regression between oil-and-gas employment per well and the direct cost per well relative to US GDP per capita (over the period when direct well costs are available). From this regression, I rescale oil-and-gas employment per well to serve as a proxy for the relative cost per well. I index this proxy to the direct data in 1939. Obviously, this well-cost proxy should be treated with appropriate uncertainty.

Further reading

King, C. W. (2020). *The economic superorganism: Beyond the competing narratives on energy, growth, and policy*. Springer Nature.