How the Energy System Really Works and What Seems to Be Going Wrong

Gail Tverberg, OurFiniteWorld.com, October 2018
Two questions:

1. What is the role of food with respect to the human body?

2. What is the role of energy (coal, oil, natural gas, wood pellets, electricity) with respect to the economy?
The world economy requires energy for GDP growth.

- Laws of physics are the problem. Note GDP growth comes first.
Other things affect the growth rate/health of the economy, besides energy

- Situation analogous to human health
  - Food choices/ amounts are not the only things that affect human health
  - Exercise matters
  - Exposure to microbes matters

- For the economy, two examples
  - Efficiency gains increase growth rate
  - Diminishing returns in obtaining resources reduces growth rate
    - In other words, growing inflation-adjusted cost of producing resources
Recently discovered: The world economy is a self-organizing structure, powered by energy

- So is the human body
- Many other examples
  - Hurricanes
  - Stars
  - Plants and animals
  - Ecosystems

- In physics terms, all are “dissipative structures”
  - They “dissipate” energy
  - This allows them to grow and change over time
  - Dissipative structures are not permanent
The economy is a complex self-organizing structure that builds up over time – somewhat like a child’s toy

- It deletes unneeded companies and products, making it almost impossible to “go backward”

Not being able to go backward makes the system **fragile**

Collapse of central government of Soviet Union is an example of what can happen to a fragile economy.

Based on 2018 BP Statistical Review of World Energy data.
Rapid energy growth is great; shrinking energy supply is a major problem.
Total world energy consumption has grown greatly since 1820.

Based on Vaclav Smil data for earlier years combined with BP Statistical Review of World Energy data since 1965.
Energy growth rates vary by decade. They were particularly high in the 1940s through 1970s.
We can separate energy consumption growth into population growth and standard of living growth.
An area graph helps show the events associated with each peak.
Troughs in energy consumption come at very bad times for the economy.
Peak coal in UK occurred at time of World War I, and Peak Coal in Germany at time of World War II. Led to Wars?

Peak Coal in UK, at time of WWI

Source: http://www.davidstrahan.com/blog/?p=116

Peak Coal in Germany, at time of WWII

Source: BGR https://www.bgr.bund.de/EN/Themen/Energie/Bilder/Kohle_Reserven_Bild1_g_en.html?nn=1547280
The economy is like a machine that strongly prefers low energy prices.
We saw on an earlier slide that rapid growth in energy consumption came in the 1940s to 1970s. Oil was cheap then.

Based on US Energy Information Administration data.
Economy is like a giant machine. With very rapid growth, Box 4 will expand much faster than Box 2.

1. Resource Providers
   - Skilled Workers
   - Unskilled Workers
   - Managers
   - Governments
   - Farmers
   - Shareholders
   - Lenders

2. Resources
   - Skilled Labor
   - Unskilled Labor
   - Crude Oil
   - Uranium
   - Iron Ore
   - Arable Land
   - Previously Built Tools

3. Economy
   Like a Giant Factory

4. Goods and Services
   - Automobiles
   - Gasoline
   - Haircuts
   - Food
   - Roads
   - Insurance Products
   - Internet Services
Everyone in Box 1 seems to benefit when the world economy is growing rapidly.

- 1940s to 1970s is the period when we would expect returns to Box 1 to be highest
  - Interest rates rising
  - Inflation rates high
  - Less wage disparity because bottom 90% of workers get more adequate wages

- This is what we see in practice, in the next slides
After 1980, both real GDP growth and inflationary changes (red line minus blue line) were much lower.
Short and long-term interest rates increased until 1981, then declined.
Inflation-adjusted wages of the bottom 90% of workers rose prior to 1968; growth fell behind the top 10% after 1980

If there is inadequate energy supply, what signs should we expect?

- **Naïve answer:**
  - High prices

- **In a networked systems:**
  - Sometimes scarcity will lead to high prices
  - But scarcity can also lead to other problems throughout the system
    - More conflict among countries; even wars
    - Low wages for less skilled workers; wage disparity
    - Low interest rates
      - Asset price bubbles, reflecting low interest rates
    - Inadequate tax revenue for governments
      - Some central governments may collapse
Today’s wage disparity seems to be reaching that of the 1930s

U.S. Income Shares of Top 1% and Top 0.1% Households – Incl. Capital Gains (1913-2013)

Source: Piketty & Saez – January 2015

https://en.wikipedia.org/wiki/Income_inequality_in_the_United_States

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What goes wrong when energy prices are high
Everyone in Box 1 is squeezed, but some more than others.

- Problem is not enough goods and services to distribute

- Young people tend to be especially affected
  - New workers cannot find jobs that pay enough

- Also
  - Less skilled workers
  - Governments – Not enough taxes
  - Lenders – Too low interest rates
  - Pensions – Not enough interest income

1. **Resource Providers**
   - Skilled Workers
   - Unskilled Workers
   - Managers
   - Governments
   - Farmers
   - Shareholders
   - Lenders
Wages/population stops rising, when oil prices rise.

- Recession occurs instead; lower average wages reflected impact of layoffs

![Graph: Average US Wages Compared to Oil Price](image)

Compared inflation-adjusted wages using BEA data with inflation-adjusted oil prices from 2018 BP Statistical Review of World Energy
There is suddenly an **affordability problem** for a broad range of goods.

- Oil and other energy prices tend to move together
  - Even food prices are in this grouping
  - Workers with low wages especially affected

- Any country with a high-priced energy mix tends to become non-competitive in the world economy

- Businesses have motivation to cut costs, any way they can:
  - Send jobs to China where wages are lower
  - In China, “energy mix” is also cheaper – mostly coal, less oil
Reach a point where no oil price works for both buyers and sellers

Oil prices are monthly averages, without inflation adjustment, based on US Energy Information Administration data.
Growing debt, at ever-lower interest rates, can help for a while
With added debt, we can miraculously pay resource providers with growing debt, not simply goods and services.

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The secret of debt: It acts like a *promise for future goods and services*

- Our problem in the last section was slowing growth in the production of goods and services (Box 4), relative to inputs
  - With the help of growing debt, the problem of inadequate goods and services can be fixed
  - The promise of future goods and services indirectly acts as a *promise of low-cost future energy supplies* to make these goods and services

- No one ever stops to question whether these promises can actually be fulfilled!
  - Promises have mostly worked in the past
  - Clearly (or not so clearly), they will work in the future
Debt with its time-shifting ability helps pull the economy forward—but it only works if the economy is moving fast enough

Human rider = Primary energy provider = Fossil fuels

Steering system = Profitability; laws

Braking system = Interest rates

Front wheel = Debt system

Gearing system = Energy efficiency

Rear wheel = Place where Energy through gearing system operates

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If interest rates are falling, the situation is even more helpful for propping up oil prices

- If interest rates are falling, monthly payments on mortgages are falling
- Monthly payment for 30-year mortgage of $300,000
  - At 10% - $2,633
  - At 6% - $1,799
  - At 4% - $1,432
  - At 3% - $1,268

- Allows more people to afford homes, at a given price level
  - Home prices tend to rise
  - Builders build more homes
  - Commodity prices, used in building homes, rise (includes oil, wood, and metals)
  - Encourages the development of oil and other energy products at higher prices
Interest rates very much affect oil prices, too

Peak inflation-adjusted prices occurred in 1980; oil prices began to slide in 1981, when short-term interest rates were raised.

Based on inflation-adjusted oil prices of 2018 BP Statistical Review of World Energy.
We also see that interest rate changes tie in with recent oil price changes. Oil price peaked in July 2008.

Monthly oil price data (not inflation adjusted) based on US Energy Information Administration data.
What goes wrong with interest rates
Falling interest rates enable asset price bubbles

- It is easy to see how home prices can be bid up with low interest rates

- Many other “investments” can be bid up to high prices with low interest rates
  - Prices of shares of stock
  - Land prices
  - Values of businesses

- If interest rates are very low, many marginal investments seem to make sense
  - Example: Oil investments in shale deposits look like they might make sense
    - Even though they are cash flow negative
    - Everyone assumes that oil prices will rise, sometime
    - Life insurance companies seem to be big investors in these, because of their high yields
Asset bubbles give a false sense of security

- Assets are reported to be worth rising $$$
- OK to borrow against them, to buy more goods and services
  - Acts to increase demand for goods and services
  - Indirectly, increases energy prices and other commodity prices
    - Encourages more marginal investments in oil, coal, gas, renewables, metals, etc.

- It is these asset bubbles that hold oil prices above $20 per barrel

- The limit to energy extraction depends upon how high the debt bubble can be made to rise
  - Higher debt => Higher commodity prices => Higher extraction
The economy reaches a point where no interest rate works

- Need a very low rate for those buying cars, homes, and businesses
  - Helps keep monthly payments affordable

- Need higher rates for pension plans
  - Have made promises they need to keep

- Higher rates also discourage mal-investment
  - Discourage investment in energy products and goods that can only exist with subsidies

- Higher rates are also helpful if governments ever wants to bail out the economy by lowering the interest rate and thus making goods more affordable
Where we are now
Oil prices are “sort of” high

Chart prepared by US Energy Information Administration
US Federal Reserve is again raising interest rates, to pop asset bubbles and lower energy prices
China is having energy problems. Coal production seems to have peaked; imports tend to be more expensive.
Worldwide, wind and solar are very small.
Energy per capita is troubling already. We seem to be headed downward again.
The world is depending on a whole lot of forecasts, as if energy consumption will rise forever, at the same rate

- Pensions
- Social Security
- Asset prices
- Future climate scenarios
Danger is collapsing pieces

- Governments of oil exporters
- Pension plans
- The central government of the European Union
- Emerging market governments
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