Insights Regarding Operation of the Energy-Economy

Gail Tverberg – OurFiniteWorld.com – June 16, 2018
Outline

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2. Today’s economy is following the path of early economies that collapsed
3. Per capita energy consumption needs to rise: Lessons since 1820
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5. Growing debt plays many important roles
6. In today’s world, debt can’t simply be forgiven
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How the economy works as an energy-based, self-organized system
The entire universe seems to be organized by flows of energy

Chaisson: Trend is toward more complex, more energy-intense, forms over time

Humans are specialized forms of animals who have learned to control energy from fire

- Controlled use of fire began over one million years ago
- Fire could be used in many ways
  - Cook food – need less chewing, digesting
  - Develop larger brain
  - Expand range
    - Use heat to keep warm
- Energy advantage allowed human population to rise
  - Die off of other species started in hunter-gatherer period
  - Later, fossil fuel energy added to this advantage
The economy has gradually been built as humans were forced by expanding population to make changes

- Needed to add more energy use
  - To accommodate rising population

- Needed to add more complexity
  - More different roles
  - More technology
  - More “promises” – “If you will do this, I will do that”
    - Early form of debt

- Agriculture is more complex than hunter-gathering
Added complexity pushes resource use toward the top of the “pecking order.” Similar to steam rising.

**Pecking order:**
- Governments
- Largest corporations
- Smaller corporations
- People at top of corporation
- People in professions
- People with college education
- People with vocational training
- People with no special training
  - Non-elite workers in system
- Governments mandate higher taxes; higher cost devices because of safety standards; need for mandatory insurance.
- Businesses lobby for lower taxes; employees with more education.
- People with advanced education usually come out OK.
- Non-elite workers have a major problem. Tend to get “frozen out.”
One way of visualizing the economy

- **Parts includes**
  - Businesses
  - Customers
  - Energy supply
  - Prices and wages set by market
  - Laws and taxes
  - Debt and interest rates
  - Pollution and control attempts

- **Non-elite workers have double role**
  - Primary workers in system
  - Primary consumers in system

If wages of non-elite workers fall too low, result can be low demand; low commodity prices.
Another way of visualizing the economy:

*Our economy* is a dissipative structure

- Acts much like a rocket, thanks to “Other Energy”
What causes the economy’s ultimate problem?

- Is it running short of oil?

- Or is it *inadequate total fuel* for the rocket
  - Economy that grows too slowly; too few *jobs* for new workers

- Or is it related to entropy issues?
  - Too much debt
  - Too much wage disparity; wages for non-elite workers fall too low
  - Too much price distortion caused by intermittent wind and solar added to grid
  - Too much pollution

- Does the problem with resources come when oil “peaks,” or *does it come sooner*? Does an economic problem *cause* oil to peak?
Physics story has been changing since 1970s

- Old story: Most systems are “energetically closed” – We “run out” of energy supplies

- New story: All of the self-organization we see in nature comes from energy flows
  - “Energetically open” systems dominate
  - Unfortunately, systems formed by self-organization are not permanent
    - Economy is one such system
    - Humans, plants, and animals; hurricanes and ecosystems are other examples

- In a finite world, everything is temporary, even economies!
  - This way, systems that are better adapted to a changing world can gradually evolve

- EROI theory was developed at a time when resource limits were considered to be the primary issue
  - Didn’t consider the possibility that other limits might hit first
EROI is like a flat map, in a world with three dimensions

- Two dimensional model
- Three dimensional model

Figure 1. Map of basins with assessed shale oil and shale gas formations, as of May 2013

Source: United States basins from U.S. Energy Information Administration and United States Geological Survey; other basins from ARB based on data from various published studies.
We don’t stop using flat maps in a three dimensional world

- But we have to be careful

- A flat map is not useful for computing the distance from Beijing to Syracuse
  - Or for seeing the true size of Antarctica compared to the United States

- EROI works fairly well, when similar fuels are compared
  - Likely to produce distorted results when intermittent renewables are compared to fossil fuels

- Model based on depletion of physical resources in *The Limits to Growth* worked well in predicting the *timing* of resource problem
  - May not work as well forecasting what happens after limits hit
Today’s economy is following the path of early economies that collapsed
Secular Cycles by Turchin and Nefedov gives details of eight economies that collapsed

- “Carrying capacity” seems to be all important

- Agricultural economies could not grow beyond the carrying capacity of the land
  - Equivalent to “Farms could not get too small, as population grew”

- Seems to be equivalent to the following ratio remaining sufficiently high

  \[
  \text{Annual Energy Consumed} \quad \frac{\text{Population}}{\text{Per capita energy consumption}}
  \]

- In other words, *per capita energy consumption* must remain high enough
  - This allows wages of non-elite workers to stay high enough
Turchin and Nefedov showed that civilizations often followed a pattern

1. A new resource became available
   - Example: Won a war; cut down land for new agricultural area; discovered irrigation

2. Population gradually grew to reach the carrying capacity
   - Energy per capita could grow, in the period before carrying capacity reached
   - Economy prospered in this growth period

3. Population growth slowed, as carrying capacity reached - stagflation
   - Required increasing “complexity” as limits neared
   - Result was more technology; more debt; more hierarchical organization; more wage disparity
   - Commodity prices “spiked”

4. Eventually collapse occurred, over a period of years
My graphical interpretation of the typical path of the eight civilizations analyzed in *Secular Cycles*

Timeline of typical collapse, based on Turchin and Nefedov’s “Secular Cycles.”
How did collapse occur?

- Non-elite workers grew too poor
  - Output of the economy disproportionately went to those in charge

- Debt defaults grew

- Governments had difficulty collecting enough taxes
  - Many very poor workers could not afford to pay much in taxes
  - Sometimes governments lost wars because they could not afford a big army
  - Had less revenue to work around climate change impacts
  - Or governments would collapse directly from loss of revenue

- Workers easily succumbed to epidemics because they could not afford an adequate diet
Is Peak Oil a new and different problem?

- Peak oil is a geologist’s view of the approaching problem
  - *The Limits to Growth* model is closer to correct
    - Gives an impression of the likely overshoot and collapse outcome

- Peak oil theory missed the point that **what is important is the total energy the economy requires** – the “necessary fuel for the rocket”

- The problem exists, whether it is the numerator or the denominator that is changing

![Annual Energy Consumed](Population)
Our civilization today seems to be following a similar path

- Started using fossil fuels over two hundred years ago

- Rapid growth in fossil fuel usage continued through late 1970s
Stagflation and growing wage disparity have been a growing problem since 1980

US income gains by the top 10% compared to income gains by the bottom 90% by economist Emmanuel Saez. From Forbes.

Per capita energy consumption needs to rise: Lessons since 1820
World energy consumption has been growing very rapidly. How fast is “fast enough”?
Energy consumption per capita has also been rising, except for two flat periods. How did these periods fare?
1920 to 1940 flat period was dreadful

- Started with peak coal in the UK in 1914
  - World War I followed: 1914 -1918
  - US agriculture was in major recession after 1920
    - Mechanization created winners and losers
    - Winners were owners of new mechanized tools; city folks buying cheap food
    - Losers were farmers who could not afford new equipment
- Roaring twenties added debt, but ended with a crash
  - Depression of the 1930s; deflation; wage disparity was at a peak
  - Smoot-Hawley Tariff Act of 1930 raised tariffs
  - Hitler and the Holocaust 1933-1945
- Ended with World War II
  - War effort created more demand for oil – new war machines and new workers in the labor force
1980 to 2000 period partly reflected a planned reduction in oil use

- After oil price spikes of the 1970s, industrialized countries intentionally made changes to reduce oil use
  - Started using smaller, more fuel efficient cars
  - Changed electricity generation from oil to nuclear
  - Changed home heating from oil to more efficient furnaces using other fuels

- Planned oil reduction indirectly caused collapse of USSR
  - Lower oil prices were a problem for oil exporters, including USSR
  - USSR central government collapsed in 1991
    - Energy consumption has never recovered for the area
Since 2010, a new period of flat per-capita energy consumption has been forming

- Seems very similar to the 1920-1940 flat period
- Falling coal consumption is again a problem
  - Many forecast future oil shortages, too
  - Tariffs again an issue
- Wage disparity is as bad as 1930s
  - This time, globalization has marginalized many workers
- Radical leaders are being elected
Conclusion: The world needs *increasing* per-capita energy consumption, or there is fighting over resources

- We can see this in the data for 1820 to 2010

- Logically, non-elite workers need close to flat per capita energy, in order for the “return on human labor” (wages) to remain high enough

- But energy available for non-elite workers is squeezed in several ways:
  1. **Diminishing returns** takes part of the total energy available
     - Ever-deeper water wells; poorer ore grades; lower EROI oil wells
  2. **Technological growth adds machines** of all types (using energy)—the return on these goes to owners and debt holders
  3. Greater complexity leads to a **more hierarchical organization and more long distance transport**—leaves less energy for non-elite workers
Thus, total energy consumption needs to rise even faster than population rises.
Now China’s coal and oil production is collapsing; world needs replacement fuels
We can’t count on energy prices rising, even if EROI falls
Fouquet shows *the price of energy services tends to fall*. “Energy services” includes both energy and its delivery.

It is falling prices of energy services that enables more use of energy products.

Growing efficiency plays an important role in falling prices.

UN world data also shows falling energy expenditures as GDP% (bottom two layers)

- Economy rebalances to the *cheapest fuels*
- Prices can fall **below** the cost of production

![Graph showing sector added value shares](image)

*Figure 2. World GDP sector added value shares*
Near limits, we reach a situation where no oil price works: Too high for buyers; too low for sellers

Price problem only appears near limit

- Appears “well-behaved” elsewhere

![Monthly Average Brent Oil Price Chart](chart.png)

- Too high for consumers
- Producers started complaining about too low prices
- Prices way too low for producers

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We have examples of low prices from inadequate demand as limits are reached

- Depression of 1930s – Farmers threw out milk, because prices were too low to justify selling it

- Revelation 19 speaks of end times being like the ancient collapse of Babylon:
  11 “The merchants of the earth will weep and mourn over her because no one buys their cargoes anymore— 12 cargoes of gold, silver, precious stones and pearls; fine linen, purple, silk and scarlet cloth; . . . and human beings sold as slaves. [New International Version - emphasis added]

- Both examples relate to lack of demand holding down prices
  - Even slaves, the energy product of the day, had little value
Illig and Schindler in “Oil Extraction, Economic Growth, and Oil Price Dynamism” (BERQ) discuss likely downward price trend

- Falling share of GDP situation exists, even after limits are reached

- The issue is that energy is important, compared to many other parts of the economy
  - The “cost share” of important quantities must shrink
  - Allows the “cost share” of unimportant quantities to grow

- This is the way the overall economy grows
Why doesn’t the model economists use tell us that prices may fall, as limits are reached?

- Economists’ model is another two-dimensional model, when more dimensions are needed

- Near limits, lack of available energy affects both supply and demand

- Demand tends to fall because of low wages for non-elite workers around the world

- Reason: Near energy limits, jobs with adequate pay for non-elite workers tend to disappear even more quickly than goods and services disappear

The limit on fossil fuels is likely a low-price limit

- Estimates of future production are likely to be too high if they are based on resources and known technology
  - Even peak oil estimates are likely too high

- Climate change researchers have missed this point
Growing debt plays many important roles
Debt is a promise for future goods and services

- Debt is equivalent to a promise that **sufficient inexpensive energy will be available in the future**, to provide these goods and services
  - Of course, no one has actually measured this

- Several different promises are very similar
  - Debt from banks or using bonds
  - Money issued by countries
  - Sale of shares of stock to fund a company
  - Unfunded government promises of retirement income for the elderly

- All act as promises of future energy – consider them “debt” for this talk.
Debt is needed if people plan to collaborate on a project with future benefit

- Need to buy raw materials and machines, and pay workers, before output is available
  - Debt is what bridges this gap – allows “time shifting”

- Examples
  - Hunter and gatherers
    - Grandmother will care for children, if at end of day, she will get a share of the food
  - Farmers often use debt to buy seed, soil amendments, and fossil fuels
    - Pay back debt when plants are harvested

- Businesses use a combination of debt and sale of shares of stock to fund company
  - Allows the business to pay workers
  - Buy machines and raw materials
Debt is helpful for many purposes

1. To finance business enterprises
   - Debt can be used to pay workers and to buy equipment
2. To spread out the payment for capital goods, such as homes and vehicles, over the life of the goods
3. To finance government programs (including wars) that provide jobs
4. To finance the purchase of shares of stock and assets such as land
5. To transfer “intergenerational debt” to government
   - No need to have extra children, to make certain someone will be available to take care of parents in old age
   - Allows mothers to work, instead of having several children
Increasing debt is helpful to the system, in many ways

1. It allows more people to have jobs, and thus raises “demand”
2. It allows GDP to grow
3. It allows commodity prices to be higher than they otherwise would be
   ▸ Thus, growing debt encourages increased production of energy products
4. It allows a growing financial sector, including insurance companies, banks, and pension plans
5. It acts to inflate prices of assets of all kinds, including real estate and shares of stock
   ▸ People feel richer; they can use the inflated asset prices to borrow even more money
But there are problems with adding increasing amounts of debt

1. An increasing share of the income of non-elite workers is transferred to the financial sector, leaving non-elite workers worse off financially.

2. The quantity of debt added tends to rise very high, relative to the GDP added. The last time that the US could add $1 of debt to produce $1 of GDP was back when oil prices were under $20 per barrel in 2018$. Debt is added for many purposes simultaneously; logically, EROI would need to be very high to provide the energy needed to repay the many types of debt and interest.

3. The burden of paying interest becomes increasingly heavy, unless the interest rate is very low or zero.
But there are problems with adding increasing amounts of debt (Continued)

4. There are diminishing returns to added debt.

5. If the rate of economic growth is slowing, at some point debt defaults become widespread.
   - System may collapse like a Ponzi Scheme

- We now hear about many debt problems around the world. Emerging markets are mentioned as a problem. Italy and Greece also have problems.
  - Debt limits are likely not far away
In today’s world, debt can’t simply be forgiven
Making debt “go away” leads to terrible consequences

- Assets will no longer have value
  - No one can purchase your home, without a loan
  - Value of shares of stock go to zero

- Banks, insurance companies, and pension funds will have no way to pay account holders

- Governments will have no way to collect taxes
Instituting a substitute for barter doesn’t do enough

- Really need to be able to make a promise based on the availability of future energy supplies
  - Time-shifting capability is needed

- If future energy supplies can’t be promised, then there is a huge problem
  - It is not possible to use debt (broadly defined) to fund projects that require both collaboration and a delay between action and finished output
  - “Saving up” doesn’t do nearly enough to keep the system operating
  - Banks and governments likely to collapse
Can’t banks provide a debt jubilee?

- Early governments seemed to be able to allow forgiveness for a limited number of debtors, during jubilee years
  - A specific king or other ruler often made the loans
  - These loans were not used to create assets for others, in the way loans are used today

- We are not in the same position now
  - Promises for repayment are now “assets” for insurance companies and banks
  - Whole systems revolve around promises of future payment
Conclusions
Conclusions

1. Resource limits seem likely to play out as an economic collapse, rather than following the Peak Oil scenario.

2. Worldwide, energy consumption needs to grow more rapidly than population, or fighting over resources is likely to occur.

3. In the 1920 – 1940 period, we hit a period when energy consumption was increasing only as fast as population growth. This was a dreadful period. We seem to be hitting a similar period now. This is the reason for radical leaders and discussion about tariffs. It may also be the reason for debt problems in Emerging Markets and Europe.
4. We cannot count on high energy prices as limits hit. The problem seems to be too low a return on human labor, when sold for its value as labor. Demand tends to fall because of low wages for the many non-elite workers.

5. We should expect actual fossil fuel extraction to be less than estimated by peak oil estimates. Low prices may cause governments of oil exporters to collapse. Financial problems are likely to reduce the amounts consumers can afford.

6. There is no possibility of a “steady state” economy. The way the economy is structured, the only possibilities are growth or collapse.
Conclusions (cont.)

7. When overall energy consumption per capita is not growing, the amount of energy services getting back to non-elite workers tends to fall. This makes these workers more susceptible to epidemics. It also makes it more difficult for the system to adapt to changes in climate.

8. Given the way that the economy is structured, we should expect debt to rise much more rapidly than energy consumption and GDP. The only situation where this would not be the case would be if fuels have very high EROI, similar to when oil sold for less than $20 per barrel, in inflation-adjusted terms. This perhaps corresponds to an EROI of 50:1 or higher.

9. Walking away from current debt and starting over does not appear to be an option.
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