Energy and the Economy: The Mirror Image Problem

Gail Tverberg, FCAS, MAAA; March 14, 2017
The economic story is extraordinarily difficult—the mirror image is also important.

One reason for the mirror image problem

- *Producers* and *consumers* of energy products are both important

- Energy prices can be *too high for consumers*

- Energy prices can be *too low for producers*

- Both problems are equally important
  - World economy cannot operate without both being satisfied
  - Either a *too low* or a *too high* price is a problem
Price problem only appears near limit

- Appears “well-behaved” elsewhere

![Monthly Average Brent Oil Price Graph]

- Too high for consumers
- Producers started complaining about too low prices
- Prices way too low for producers
We know oil exploration and production costs have been rising rapidly since 1999.

Figure by Steve Kopits of Westwood Douglas. CAGR is compound annual growth rate.
This is a different problem than most early modelers supposed

- Economy is a complex adaptive system
- Energy part of system is reaching *diminishing returns*

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6  [Leonardo Sticks toy](http://www.rinusroelofs.nl/structure/davinci-sticks/gallery/gallery-01.html)
Economic Growth in a Networked Economy
One key to economic growth: Tools

- Energy products + mineral resources can be used to make tools (broadly defined)
  - Axes, knives
  - Machines
  - Roads
  - Vehicles
  - Computers

- If humans use these tools and “technology,” they can become more productive

- *Rising quantity of tools* leads to growing productivity
Making and using these tools requires *energy*

- Partly human energy
  - Design the tool
  - Operate the tool

- Partly energy from energy products, such as diesel or electricity
  - Used to extract the minerals needed, and form them into tools
  - Used to operate the tools

- These tools *leverage* human labor
  - Rising use of tools *increasingly leverages* human labor
  - Tends to produce economic growth: more goods per hour
    - Economists misname this “rising worker productivity”
Making these tools also requires debt

- Problem with tools: benefit is all in the future

- Need to create tools using human labor, plus energy and mineral resources, before the benefit is received
  - How can the economy pay for these tools?
  - Debt and debt-like instruments
  - Selling shares of stock acts like debt as well

- Using debt, it is possible to pay workers now, for the future benefit that tools will provide

- Need for debt, besides energy, is second part of mirror image problem
An economy produces goods and services

Growing quantity of energy products and other resources

Growing number of workers

Growing supply of ever-improving “tools”

Growing quantity of goods and services produced
How should the output be divided? Adding debt *provides enough to pay everyone*

- Owners of Growing quantity of energy products and other resources
- Growing number of workers
- Owners of Growing supply of ever-improving “tools”

Future Goods and Services

Growing quantity of goods and services produced

Includes Interest
There is enough to pay everyone through magic of debt

- Owners of resources often paid in stock or in debt
  - Debt is promise of future energy and what it makes possible

- Part of wages of workers saved for future
  - Goes into savings for retirement
  - Down payment on home; college education for kids
  - Keeps the benefit as a theoretical future benefit
Debt and quasi-debt take on many forms

- Earliest quasi-debt:
  - I will hunt; you will gather; obligation to save output to share

- Debt can be money, whether gold coins, paper, or pixels
  - Government guarantees that “bearer” can buy something later
  - Similar to “store credit” when a person returns an item

- Debt can be issued by banks
  - Another form is bonds issued by companies

- Shares of stock act very much like debt
  - Promise dividends and ability to sell shares later
Debt becomes very important in how the economy operates

- Amount available to “pay” the various players depends on the size of the outer circle—more is better!

Amount available to allocate with increasing debt levels

Real amount of goods and services to allocate

Includes ever more promises for interest payments
It is the **increase** in debt that raises wages and raises affordable price of commodities

- A **decrease** in debt (or too small an increase) shrinks wages and prices

Amount available to repay *current* workers and owners

Amount of goods and services actually produced
Maximum energy supply determined by “demand”—should be called *affordability*

1. Wages of non-elite workers
   - If can’t afford houses, cars, reduces “demand”

2. Extent of debt increase
   - Raises demand, and hence prices

3. US dollar level compared to other currencies
   - Oil and other energy mostly priced in US$

4. Extent to which productivity is rising
   - Depends on *increase in energy consumption* for tools
Debt levels and interest rates have a huge impact on commodity prices.
Debt levels need to keep rising to maintain economic growth

- Amount of debt required to produce a given amount of GDP growth increases as limits approach

- Interest rates are squeezed very low to hide high debt level

- Ever-rising debt levels are like a Ponzi Scheme
  - Must fall over, as diminishing returns hit
  - If fall over, likely to take banking, insurance, and pension plans along

- Debt forgiveness was possible in days when all debt owed to a king
  - Problem now: “Recycled debt” being used as an asset in banks, etc.
Growing efficiency should help, but technology reaches diminishing returns

The Physics Problem We Should Be Modeling
Physics problem: Our economy is a dissipative structure

- Dissipative structures self-organize and “grow” when flows of energy are available. Examples:
  - Hurricanes
  - Stars, including the sun
  - Ecosystems
  - Plants and animals

- Each type of dissipative structure is a little different

- Energy flows are essential to the operation of dissipative structures

- All dissipative systems are temporary
  - Grow and eventually collapse
An ecosystem is a dissipative structure.

**Inputs**
- Solar energy
- Minerals in soil
- Soil and water

- Ecosystem never grows beyond what sun’s energy can support.
- No real waste; everything recycled.
- Tends to collapse when very sharp fluctuations occur.
Our economy is a dissipative structure

- Acts much like a rocket, thanks to “Other Energy”
Clearly, an economy that acts like a rocket cannot continue forever

- **Problem 1:** *Rising cost* of producing energy products
  - EROEI considers some aspects of this

- **Problem 2:** *Quantity* of energy needs to keep rising
  - Growing tool use
  - Rising population
  - Prevent *debt defaults*
  - Repairs to built infrastructure

- **Problem 3:** *Entropy* related issues
  - Rising debt
  - Growing pollution
  - Growing wage disparity
  - Climate change
  - Intermittent renewable electricity *distorts prices of other fuels*
Idea that renewables can replace “Other Energy” (Slide 24) is a **myth**

- Adding renewables adds “tools and technology”

- Tends to pull “goods and services” away from workers
  - Especially non-elite workers (Slide 12)

- Requires increasing education for some, but not others
  - Leads to growing wage disparity

- Requires rapid rise in debt
  - Leads to greater wealth disparity

- Tainter: “Increased complexity” was primary cause of earlier collapses – wage/wealth disparity problem
Ability to run the economy on solar electricity is a similar **myth**

- Electricity is the “high-priced” product per delivered joule of energy
  - Also, solar electricity available only part of the time

- Equivalent to trying to run an economy using only PhDs for labor
  - These PhDs only work between 9am and 4pm
  - Take off a great deal of time in winter; bad weather

- In theory, could rearrange economy to operate with robots in remaining time periods
  - System would never work – way too expensive with all PhD salaries
EROEI seriously overstates value of renewable energy

- “Fossil EROEI” is suitable if our problem is “running out” of fossil fuel energy
  - Real problem is much more complex

- A major need is to keep the wages of non-elite workers high enough
  - Equivalent to keeping return on human labor high enough
  - This is a different kind of EROEI
  - Equivalent to required return on labor of animals, studied by ecologists
EROEI calculation not suitable for intermittent renewables

- Calculation is \( \frac{\text{Energy out}}{\text{Energy in}} \)
- Has no time variable
  - Cost of capital assumed to be zero
- Misses non-energy costs, such as land leases
- Traditional analysis is “at wellhead”
  - Misses high delivery costs, including long distance transmission
- Intermittent renewables require a double system
  - Pricing system forces needed backup producers into bankruptcy
- Misses contribution to wage disparity; wealth disparity
  - Also doesn’t consider huge amount of debt required
In the end, it is simply dumb to think that the system will automatically collapse when and because the net energy of the oil production process becomes negative (or the EROEI smaller than one).

No, it will crash much earlier because of factors correlated to the control system that we call "the economy". It is a behavior typical of complex adaptive systems that are never understandable in terms of mere energy return considerations.

Complex systems always kick back. (February 26, 2017)

*BioPhysical Economics and Resource Quality
Source: http://cassandralegacy.blogspot.com/2017/02/peak-oil-catastrophism-is-popular-but.html
Where We Are Now
There are no good energy fixes in sight

- Efficiency through technology reaches diminishing returns
- Renewables don’t really work
  - Too small scale
  - Too expensive
  - Tend to over-use natural resources
  - Pricing of intermittent electricity detrimental to backup fuels
  - Cause wage/wealth disparity
- Nuclear is not working now either
  - Cost too high
  - Major providers (Toshiba, Areva, FirstEnergy) have huge financial problems
If the economy could grow forever, popular beliefs would be correct

- Debt could be repaid with interest
  - Insurance companies, banks, and pension plans would do well

- Energy prices would be high enough for producers, and not too high for consumers
  - We would expect our biggest worries to be climate change and pollution

- Our concern might be shortchanging our children, by failing to act now on climate change
  - But really there are no energy fixes for climate change
We have multiple problems

- **Problem 1.** No dissipative structure can last forever.

- **Problem 2.** As a dissipative structure, our economy seems to be reaching its end.
  - Partly because of slowing growth in energy consumption
  - Partly because of growing wage disparity.

- **Problem 3.** We have ramped up recycling of debt as assets to an amazing level.
  - This debt recycling prevents debt jubilees
  - Leads to the likelihood that insurance companies, banks, and pension plans will fail, if the economy fails
Problems appear to be not far in the future

- Financial system is likely to be center of the storm
  - Most EROEI analysts miss this point

- Economy cannot shrink without debt defaults

- Economy doesn’t have the ability to go backward
  - Transition to using horses for transportation would be difficult

- Theory says that new somewhat similar dissipative structures are likely to eventually form
  - Depends on how many can survive the coming contraction
  - Also, how depleted resources are
  - If contraction too severe, no new economy may be possible
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