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Jevons' Law: Enforcing the Age of Energy Decline - Part 1

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This is a guest post by Lionel Orford. Lionel is a professional electrical engineer with an interest in peak oil and sustainability. This past year he has been researching and developing a book with the working title, "Peak Capitalism: Our Opportunity to Choose between Transformation and Collapse." His web site can be found at this link.

In his 1865 book "The Coal Question: An Inquiry Concerning the Progress of the Nation, and the Probable Exhaustion of our Coal-Mines," English economist William Stanley Jevons made the observation "*Of the Economy of Fuel*" that when improvements in technology make it possible to use a fuel more efficiently, the consumption of the fuel tends to go up, not down.

This is known as Jevons' Paradox. It occurs because as the efficiency of a type of machinery is improved, it becomes profitable for many more customers and feasible to apply it to new applications. This results in rapid growth of the number of machines in use and consequently, an increase in fuel consumption overall.

Jevons' observation was made regarding the application of coal power to steam engines. The first commercially applied steam engine was invented by Thomas Newcomen to pump water out of coal mines. It used a very large amount of coal compared with the amount of useful pumping it achieved and was only viable at coal mines where coal was plentiful and ready to hand.

When James Watt recognised that a major improvement could be made by using a separate condenser vessel, he built an engine that was so much cheaper to run that applications for it blossomed. This enabled Watt to go on to further increase the level of technical sophistication and efficiency of his engines. This led to the common belief that Watt 'invented' the steam engine.

In 1865, when Jevons published his now famous paradox, steam engines were only efficient enough to be used where they could be frequently refuelled, such as for stationary applications (mines and mills), railway locomotives, harbour tugs and paddle steamers. They were not efficient enough to carry enough coal to cross oceans and still have room for cargo. The subsequent development of the triple expansion steam engine, which was markedly more efficient, made ocean going steam ships viable. Consumption of coal again escalated, as Jevons had predicted.

This dynamic has now played out in several technologies, notably:

• The development of modern fan jet engines for aircraft that have increased efficiency (passenger mile per unit of fuel) of jet airliners by 3 fold from the Boeing707 to the Airbus380. The result – rapid growth of air travel and fuel used.

• The development of modern high efficiency coal fired power plants. The result – exponential growth of electricity used and greenhouse gas produced.

• The development of efficient and powerful computers that can be manufactured very cheaply. The result – exponential growth of the amount of energy used for manufacture and running of computers.

As is implied by the full title of the book, Jevons' concern was that the exponential growth of consumption of coal he was observing would result in the exhaustion of economically viable sources of coal. He warned that coal production would inevitably migrate away from the easily mined deposits near the surface to the deeper deposits that would require more capital and more labour to extract. He predicted that British coal would become increasingly expensive to the point that more and more applications would cease to be profitable. He concluded that this would result in the eventual reduction in coal production and industrial output with potentially disastrous effects for the British economy.

About a century before M King Hubbert's prediction of Peak Oil, Jevons was making very similar observations regarding Peak Coal. The ideas of both men were denied and even ridiculed by their peers, but both have subsequently been proven correct. British coal indeed did peak in 1913 and almost no coal industry remains in Britain today.

This didn't result in disaster for the British economy, but only because of the rise to prominence of a new fuel – petroleum – which Jevons could hardly have predicted. Oil partially replaced coal and also enabled another technological revolution that made it viable for coal to be imported into Britain.

What Jevons was noticing was that as more useful work (more utility) was obtained from a given amount of fuel compared with the amount of work it took to get that fuel, the more profitable applications there were, and hence, usage increased as more and more applications emerged. That's the now famous part of what Jevons had to say. What is less well known is that he realised that the reverse would also be true as the work required to get the coal increased comparative to its utility.

Like Hubbert a century later, he was widely misinterpreted as saying that we were "running out of coal", when he was actually realising something much more subtle – that coal would become too expensive to be profitable and would decline due to a lack of demand – not that there would no coal left in the ground. Indeed, something in the order of 70% of Britain's coal endowment is still in the ground today. The parallel with our current situation regarding oil is blindingly obvious – we are not running out of oil; we may never completely run out of oil; *oil will simply become too expensive as more productive capacity is needed to supply it and demand will decline accordingly*.

Scientific laws are based on observations that over time prove to be such a reliable basis for predicting the behaviour of a natural phenomenon that they are elevated beyond hypotheses, beyond theories, to a status where they are recognised as laws. Examples include Newton's Law of Gravity, Faraday's Law of Electromagnetism and the Laws of Thermodynamics. I propose that

it is now time for the recognition of **Jevons' Law**:

> **As the utility provided by an energy source increases or decreases in comparison to the amount of utility expended to obtain it, so does the overall usage and utility provided by that energy source, over time.**

I use the term 'utility' to mean 'work of real economic value' or 'productive capacity'.

I hasten to point out that I am not putting this up as a fundamental law of the universe like the scientific laws mentioned, but contend that it is least as secure as any so called "Law" involving social sciences such as White's Law and is actually valid over the long term, unlike that piece of techno-triumphalist nonsense - Moore's Law. Also, I am not saying that Jevons stated this definitively, but that it can be concluded from the arguments he makes in *The Coal Question*.

It is important to note that this law doesn't apply on an instantaneous basis, but has a lag effect that extends over decades. In the short term, it is possible to disobey Jevons' Law, particularly by distorting the market – for example:

• Although the long term price of oil must be determined by its cost of production, economic booms, speculation and supply squeezes can send the price spiralling way above the cost of production, resulting in subsequent demand destruction.

• Government subsidies can push the uptake of an uneconomic energy source for social and political reasons – e.g. subsidised petrol and diesel, biofuels, wind power, nuclear power.

• For OECD economies, particularly the US, a deficit of economic productivity gained from importing oil compared with the cost of those imports has been masked by an economic feeding frenzy of consumption, financed by escalating overall debt comparative to the productive means to repay that debt.

I contend that such distortions of the market are unsustainable over the longer term. Speculators lose their money when speculative activity drives prices to levels not justified by the cost of production; countries suffer from misguided government subsidies that waste their national wealth on uneconomic programs; and debt bubbles always end in financial ruin.

In terms that are familiar to this readership, Jevons' Law is very closely related to saying – *The use of an energy source rises and falls in accordance with its Energy Returned on Energy Invested* (EROEI). However, this is not strictly true because energy does not directly equate with utility.

A particular case in point: The EROEI of oil has been declining since before Jed Clampet "went out huntin' for some food, when up through the ground came a bubblin' crude", but this has not caused the demand for oil to fall. I contend that this is because, even as the cost of production has steadily increased, the amount of utility obtained per barrel of oil has increased substantially faster due to increases in efficiency of machinery and the development of new applications, such as jet airliners, which provide enormous utility compared with the oil they consume. These new applications have been the basis for a whole range of service industries that also have real economic value. Jevons' Law has held true.

We seem to have now reached the point where the investment of capital and labour needed to

increase the supply of oil is no longer justified by the additional economic value that it provides. Beyond this point, the use of oil will be relentlessly forced into decline.

The oil industry is now in a vicious circle whereby huge investment is required even to maintain the supply of oil. This investment can only be justified by reliably high prices for oil in the order of $100 per barrel, but it is quite clear that the world economy cannot maintain demand for oil in that price range. Hence I am of the school of thought that argues that this investment will not be made, that decline of both demand and production is inevitable, and that Peak Oil is now behind us. Time will tell.

A declining oil supply spells certain death for our economic system because it relies on growth to remain viable and that growth is in turn reliant on commensurate growth in oil supply. It is nonsense to believe that we can continue to grow the economy by growing areas of enterprise that are not dependent on oil such as finance and other services or by continuously improving efficiency to gain more economic value from less oil. The financial and service economy is only as strong as the productive economy on which it feeds. Although some efficiency gains are possible through frugality, such as using public transport rather than private cars, these changes can only be made over many years, and such frugality would result in reductions in economic size overall, rather than growth. For example, if most of us used public transport, there would be dramatically reduced market for cars and the service industries they support. This is Jevons' Law in action.

Furthermore, our cultural addiction to oil and economic growth has led us into a condition of overshoot, where we have been spending more to obtain oil than the economic value generated from it for decades. This has been a major factor in the accumulation of vast debts by western countries, most of all the USA. The accumulated debt seems to be way beyond our productive means to repay, which is effectively the definition of bankruptcy.

The only probable outcome from all this is ongoing economic dysfunction, as governments and the corporate sector repeatedly make futile attempts to return to business as usual, leading to the eventual collapse of the current economic system. This dysfunction is likely to be accompanied by a corresponding crash in both demand for oil and investment in new oil production.

As the economy fails, there will be great social hardship as millions of people are rendered unemployed, and there will be great political tumult as the electorate holds the government accountable for their great loss. I contend that this process is now underway and unstoppable.

However, while economic crashes happen relatively quickly, cultures change over much longer periods. When things get tough, modern countries do have a track record of dealing with their problems somehow, rather than undergoing societal collapse. Modern examples which have suffered economic collapse, but avoided societal collapse, include Germany, Argentina, Russia and, most recently, Iceland. However, if we continue to deny and mismanage our situation, we could proceed through all of Orlov's Five Stages of Collapse, and catastrophic collapse of our society could be our fate – as it was for the Easter Islanders, the Mayans, and others.

We do have a culture capable of solving problems – but only when it is widely understood by the general populace that emergency measures and major changes are required. Once we shift to emergency mode, we can overcome our cultural resistance to change and make major changes to the way we operate our society. I believe (and hope) that once the failure of our economic system becomes obvious to all, we will have an opportunity to form the political will to make the fundamental changes required to avoid catastrophe.

In Part 2 of this article, I will examine what is required to deal prudently with the reality of

energy decline and economic collapse that is imposed upon us by Jevons' Law, so as to steer away from societal collapse.

Note: For further background on the economic issues raised in this article, I recommend Chris Martenson's Crash Course.