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Implications of the Ayres Warr Model of Economic Production: An Introduction

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This is a guest post by Ian Schindler, known on The Oil Drum as Schinzy. Ian teaches math at the University of Toulouse in France.

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Schinzy

Many Oil Drum readers are familiar with the Ayres Warr model of economic production, as discussed in "Accounting for Growth: The Role of Physical Work" by Robert Ayres and Benjamin Warr. As a mathematician, with an interest in economics, I wrote a fairly mathematical paper, extending some of the work done by Ayres and Warr. My paper can be found at this link.

The purpose of this post is to give an overview of the paper I wrote, explained in more elementary terms. Some readers with a more mathematical bent may choose to read my original paper as well. For those readers unfamiliar with the Ayres Warr model, a short introductory piece can be found in point 5 of this post by Gail the Actuary.

Ironically my interest in economics has largely been unmathematical. I have colleagues who are economists with whom I have spoken about both economics and their mathematical models. The models they showed me in general did nothing to improve my intuition of economics. I had always attributed this to a lack of systematic study of economics. Then I learned of the Ayres Warr model of economic production. The more I thought about this model, the more it seemed to make sense to me, and the more of my eclectic knowledge of economics it seemed to explain. I started reading papers of Ayres and Warr, among other papers on economics. The economic analysis I have read most in tune with the Ayres Warr model of economic growth is that written by Gail the Actuary.

The Ayres Warr model of economic production is remarkably simple. In my view, it is like a first simplified model which gives the main story, but which may be modified in the future. In particular, it is missing a stochastic or quasi periodic term with zero average. It says that exergy, or the proportion of energy produced which is available for work, produces most economic output. The rest is essentially produced by capital. Exergy roughly corresponds to efficiency times energy production. Efficiency depends on technology as does energy consumption. A major implication is that peak energy production will roughly coincide with peak economic output. The model is consistent with attributing units of energy to currency.

I made some simplifying assumptions and did some elementary analysis on the Ayres Warr model and came up with an equation from which I arrived at the following conclusions implied by the model:

1. Price swings of energy produced by changes in energy supply are mitigated by changes in economic output. If production of energy increases, this creates greater economic production which increases the market for energy, thus damping the price decrease. Inversely if production of energy decreases, economic output decreases damping the price increase.
2. Energy efficiency increases the price per unit of energy. This can be understood in two ways. Increasing efficiency increases exergy, thus increasing economic production which increases the market for energy thus increasing the price. Second: the more work one can do with energy, the more one is willing to pay for energy which increases its worth. So increased energy efficiency is the greatest driver of economic growth, stimulating both the economy and energy producers.
3. Energy efficiency does not limit production of fossil fuels; it raises prices stimulating production. Therefore many policies people are encouraging to limit global emissions will in fact raise global emissions. If there is a threshold beyond which we cannot burn more fossil fuels, and it is commercially viable to produce beyond this threshold, the only way not to cross it is by sacrificing economic output.
4. Increasing efficiency ultimately increases energy prices which we need to assure future (renewable) energy production.
5. The Ayres Warr model is possibly a good tool to detect financial bubbles and troughs (periods in which the market over or undervalues assets) when they are due to over or under estimating economic output. For example increased exergy production during the 1990's implied that the world economy was growing robustly, so that oil was probably under priced in 1998 (at $10 per barrel). On the other hand, flat exergy production since 2005 was a portent of lower economic growth, thus a decrease in demand for oil so that the price of oil in July 2008 was probably too high.
6. Economic output is largely independent of population. Therefore demographic concerns that there will not be enough future workers to support an aging population are unfounded. Concern should rather be that exergy supplies will be insufficient.

The last item did not come from the equation I came up with, it is a direct consequence of the Ayres Warr model. It can be understood as meaning that population is a possible expression of increased economic output (made possible by increased exergy production), but not a necessary one. In addition to these conclusions, my analysis suggested very simple feedback loops to explain economic growth and contraction.

I have just begun my investigations of the Ayres Warr model of economic production. By talking about it, I'm hoping that others will join me in looking at implications of the model, and integrating the model into simulations to see how well it can predict future economic output and energy prices. Having a reasonable estimate of the future economy has considerable political ramifications. Much policy debate is based on maximizing future economic output. If the Ayres Warr model is a reasonably accurate model for future economic production, much of this debate would be cut short, and we could focus more on how we plan on using the economic production available. We also might question whether maximizing economic output is the best way forward.