The curious case of Stimulus as Constraint

promoting growth to slow resource depletion

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Abstract

A seemingly obvious error in economic systems thinking appears to have persisted in popular culture despite being well enough understood by some economic systems scientists for about 150 years. As a result the kinds of profitable efficiencies used for business expansion have become relied on for resource conservation, a highly consequential error repeated around the world. Why the issue got confused seems to be that few understood that efficiency has both cost reduction and productivity increase effects, and both needed to be counted, and what has been missing is a concept of "total" for the net effect to be calculated. The problem exposes some of the pitfalls of knowledge, a fascinating story of how separate explanatory languages come to talk about different things, developing terms of discussion that don't connect with each other, or apparently even with the physical world. Conversations develop as cells, and then address different aspects of whole systems as being separate and unconnected, when they're not. Very simple energy budget concepts for the economy as a whole help clarify the meaning of the data, showing the whole effect of efficiency on the rates of global resource use. The writing tells the story as somewhat of a mystery narrative of nature, science and practice. Brief discussions of the telling evidence and the critical issues of the science lead to considering how specialized languages could refer to the same common subjects and so inform rather than confuse us by their differences.

KEYWORDS: efficiency effect, Jevons, whole systems, whole effects, costs, productivity, growth, language gaps, scientific methods, sustainability science, natural systems

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Introduction

By all counts sustainability science and policy communities should be in turmoil, but isn't, for having long ignored the clear evidence that our main sustainability policy at this critical time in history generally has the opposite of the intended effect. Cultural logic can trump clear evidence of natural physical consequences, and so adherents may remain unimpressed, and not disturbed by the apparent physical reality at all. Tasks done more efficiently use fewer resources, yes, but the main reason businesses invest so much in them is to make using resources more profitable and allow greater resource use, not less, or so the evidence shows.

The approach here will be unfamiliar to many, as if approaching the question "backwards" by starting from the clear evidence as "proof" to then look for a theory to explain it[1]. For not knowing how to do that, the world consensus sustainability policy for reducing economic impacts developed by popular consensus instead of by studying the accumulative affect of efficiency on the world economy that has always beeb to increase business impacts and resource depletion. Various others have firmly reached the same conclusion (Jevons 1885, Saunders 1992, Hall 2007) but the

[1] The scientific perspective used here was first published in Cosmos & History V6 No.3 as "Models Learning Change" by the author. http://www.synapse9.com/pub/ModLearnChange.pdf , stemming from a discovery about the physics of continuity that allows mapping the cellular structure of natural systems including systems of social agreement.

cognitive disconnect between the physical reality and popular theory has yet to be made a focus in other discussions.

The problem could first appear to be our simply not believing the clear data. Looking closely at why we don't, though, points to a deeper misunderstanding of the physical world and how both our popular and scientific languages get disconnected from each other. No one understands the whole world scientifically, only the parts of it that our explanations seem to apply to. Our most common terms for discussing the world we live in develop as metaphors and explanatory stories through social and professional relationships. Since that establishes our way of referring to the world, as our own cultural constructs, we regularly slip into treating the world as being our own cultural constructs. It's problematic. It leaves us now interfering with planetary systems at an ever increasing scale, treating nature if it worked by our own '*mental maps*'. We let our social constructs take precedence by taking our eye off '*the territory*' of observable physical relationships in nature that our explanations need to help us understand. The result is partly that a world consensus policy for delaying resource depletion now seems to be a primary cause of our ever increasing rate of resource consumption.

If popular social constructs control the terms of discussion then policy is based on metaphors taking the place of real theories about the effects we observe. The most troubling results of these '*mistaken identities*' for nature are the compelling solutions to problems that also multiply the problems they were intended to solve, like stimulus used for constraint. If the terms of policy are based on social constructs then valid theories based on careful observation can't be communicated, even to simply convey that a particular policy is clearly not having the stated effect.

One of the intriguing parts of this is that it's never been possible to speak to anyone except in their own language. Thus, if our languages seem disconnected we need to find what they have in common. What they have in common seems to be the origin of all language in pointing and gesturing. Pointing and gesturing makes the common subject of language the physical world that we experience in common, beyond the definitions of language. In complex modern languages, though, the subjects of physical experience are often replaced by subjects internal to the meanings of the language itself. It lets their meanings become '*externalities*' to other discussions, detached from the common subjects as if we lived in multiple realities.

The intent here is to somewhat carefully dissect the one critical policy problem of using efficiency for both economic stimulus and constraint at the same time. The philosophy of science issues are raised more to suggest that looking at how our socially constructed maps of the world become disconnected can be a fruitful territory itself. For example, just as science finds it hard to offer advice on policies for popular social constructs of reality, it also brings into question why the sciences usually limit themselves to subjects that are well defined in their own socially constructed terms. What is unavoidable in nature is that much of importance in the world can only be identified by pointing and gesturing, while remaining quite indefinable. Social and professional cultures and their language developments are themselves distinct and identifiable physical phenomena of that kind. They're of great importance to recognize and understand, but easily misrepresented by being defined.

It's not just the difficulty of formal or mathematical definitions and how models tend to represent whole complex systems with one dimensional numbers that make definitions ill-suited for representing nature. It's also that definitions are made for categories of similar things. The world is full of highly individual systems with constantly changing organization that emerge from their own indefinable environments. They don't really fit into categories and need to be addressed individually. This seems to expose an interesting gap in the scientific method. It leaves us steering a planet on matters of great consequence with a loose mix of separate under-defined and over-defined terminologies for how to do it. The result seems to be that people get confused and argue instead.

Does efficiency slow resource depletion?

The data shows continually improving economic efficiency along with ever faster rates of increasing resource consumption throughout modern history. Since the early finding 145 years ago (Jevons 1885) that profitable efficiencies naturally accelerated growth and resource consumption various communities have voiced conflicting opinions on the subject (Tainter, 2008). In reviewing the present literature (Henshaw, 2010) the environmental movement appears to have developed around the contrary view that efficiency efforts would have the same effect as environmental habitat conservation, i.e. a direct additive effect. How we then came to rely on it as a world policy for using profitable efficiencies to prevent resource depletion in general apparently occurred without actual study. In recent years there have been relatively few journal articles on the subject of whether improving efficiency could reverse the long trend of increasing consumption, or if it would have the opposite effect as originally observed by Jevons. Only about three dozen direct citations on the question were found. Some were conclusive on both sides, but most concluded that the traceable effects of efficiency are to reduce resource use, but untraceable effects might contribute to the observed trend in the opposite direction. So, the majority of authors seemed to say both theories were plausible, even if one predicts the opposite of what is observably happening.

What gets lost in giving credence to undemonstrated theories is how it gives people confidence, if they want to believe in them, in policies that are demonstrably ineffective. Efficiencies of all kinds have been improving steadily throughout history as resource use and depletion rates have accelerated. Public policy, though, is now clearly being guided by the popular conviction that the opposite will occur, having no scientific consensus that it reliably could, nor any explanation for why it never did. The principle that energy conservation and efficiency should reduce energy use appears to be treated as a matter of freedom of speech or religion. We end up feeling obligated to treat undemonstrated physical science as having merit as public policy, if the idea is pleasing to us. What it exposes is how dependent people are on their cultural models. The interesting twist is how far that extends. It seems to go so far as to keep us from believing what we plainly see occurring until we have a socially acceptable explanation for it. We seem to prefer to see the "*naked emperor*" as wearing what everyone says he is whether he visibly is or not.

The real “Jevons’ paradox”, then, seems to be that we can believe an unsupported theory that fits our cultural values when we don’t have a good explanation for the easily observed evidence to the contrary. The apparent extension of that was for a world consensus sustainability policy to be adopted without expert study to determine the likelihood of it working. The bottom line, though, is that policy makers have a fiduciary responsibility to adopt workable policies, respecting the real interests of others. That is not satisfied by just going along with popular ideas of how people would like the world to work.

What seems a better explanation for the observed connection between efficiency improvement and resource use was first presented to the 2009 BioPhysical Economics meeting (Henshaw, 2009). That talk also covered a range of other effects of efficiency in natural systems at different stages of their growth and development. Those other effects include accelerating developmental processes in some circumstances and making them inflexible and intolerant of change in others.

In explaining the efficiency effect on resource use the factor most overlooked is that the main purpose of investing in efficiencies for business is to expand their businesses. They make use of the market response to having more effective products at a lower cost to sell. The main purpose of investing in efficiency is then to enable the expansion of resource consumption. What advocates of using efficiency to cause decreasing resource use have focused on is how it often reduces the resource costs of home or business operations. That overlooks the main purpose, that efficiency is used to be able to do more of other things. For business, increasing sales and profits for further expanding the business is the real objective. For both individuals and businesses efficiency also helps maintain a competitive advantage in their work market, and for business to keep from falling behind and loosing investors.

The productivity effect and the cost reduction effect occur somewhat independently seems to be the catch. Why the productivity effect is larger is that people and businesses choose to invest in the efficiencies with the greatest productivity. Those are the efficiencies using a little less of one resource to amplify the use of *other* resources. That's the key to understanding it. It's not how making a better hammer lets you use lighter materials for the handle, but that more carpenters can use them to drive more nails more easily. It's saving some of one thing in finding how to do more of other things, like removing bottlenecks to release a flood of other resource uses. That effect '*expert know-how*' for profit becomes the main purpose of efficiency, producing more with less. Promoting that normal strategy for increased resource use with the intention of having the opposite effect is using a stimulus as a constraint.

Some examples of how efficiencies are used to remove bottlenecks to let you do more, reducing the use of one thing to increase the use of others:

1. *Greater fuel efficiency lets you drive further (York, 2006) possibly making commuting more affordable so people can live further out of town and in bigger homes.*
2. *Computer designed architecture makes it easier to replicate designs so fewer people can build more buildings at less cost and further expand development.*
3. *Water saving appliances let developers build larger sub-divisions and drip irrigation creates larger farming communities in the desert (NY Times, 2008).*

4. Even such things as the business community movement to promote creative business cultures and supportive work environments are driven as being more efficient uses of the knowledge and capabilities of employees for increasing business products and profits. (Casson 1994).

This use of efficiencies to increase resource use is very consistent with the dominant effect we see in the data. Figure 1 shows 35 years of IEA world data on GDP and energy use, along with the ratio of GDP/energy as economic energy efficiency. The GDP curve is scaled to 1.0 at 1971 and the other curves are scaled in proportion to GDP according to their relative rates of growth. Scaling them in relation to their growth rates presents their relative changes of scale. Clearly GDP is growing faster than energy use or economic energy efficiency, but their proportional rates of change are constant, with each having a constant rate of growth. As world GDP and its effects have had a steady doubling rate of 22 years, energy use and its effects have had a doubling rate of 37 years and efficiency a doubling rate of 56 years.

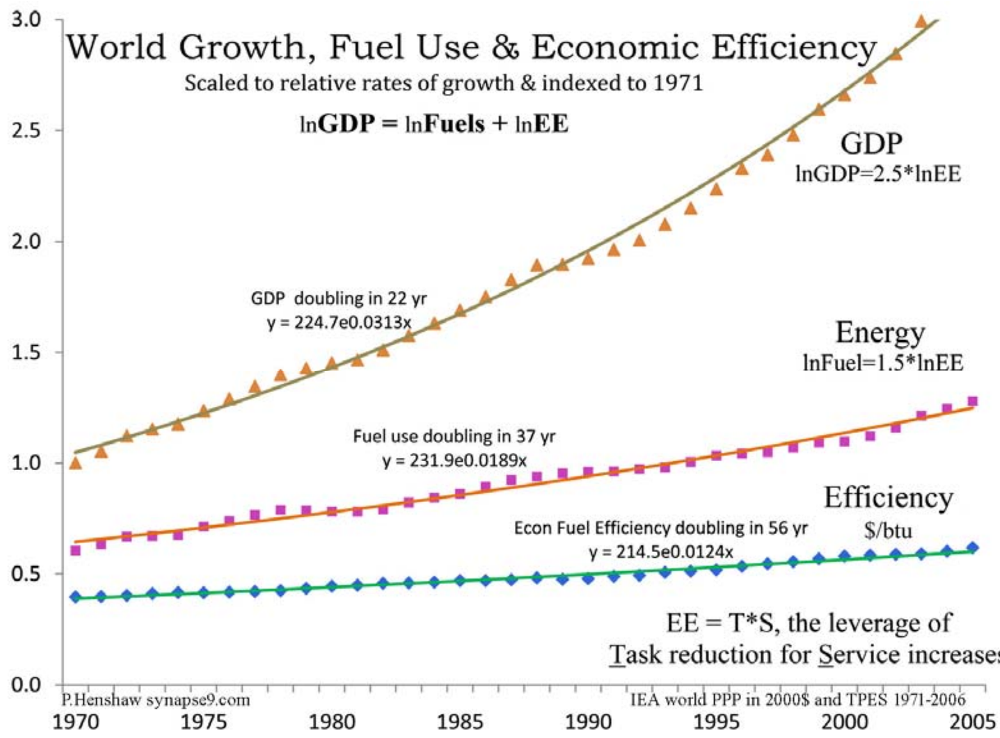


Figure 1 – IEA world data 1971-2006: Economic product (GDP in 2000$) compared to World Fuel use (TPES in Quad btu's) & Economic efficiency ($/btu), scaled by their relative growth rates in proportion to GDP = 1 in 1971.

The equations in Figure 1 show that for 1 unit of energy savings in producing GDP, GDP expands 2.5 times and uses 1.5 times the energy in total. So the added 1.5 units of energy use are the net combination of the stimulus and constraint effects of improving efficiencies. This is the direct implication of the growth rates. It also interprets improving efficiency in creating wealth with energy as why we pursue it. That does at least seem to pervade nearly everyone's learning and decision making in the economy.

For a *Constraint effect* of 1.0, the *Relative stimulus* = lnGDP/lnEE = 2.5 (1)

Net consumption *Stimulus effect* of efficiency = 1.5 = (2.5 – 1.0) (2)

Understanding complex systems and their causal linkages can be made very complex, and the best recent book on the efficiency effect, by Polimeni et al. (2008) has been somewhat criticized for letting the thoroughness of its non-linear systems approach somewhat obscure rather than clarify the issue (Bauer, 2009). It can indeed be a struggle to make valid simple explanations of complex subjects. It's a little more possible if you can find how to point to the way nature is making things simple by organizing complex systems to work as a whole. The approach above shows that way of '*working backwards*' to look for '*the question*' starting from what the physical system is doing simply as '*the answer*'. It requires stretching our questions a little sometimes to make it work, so they at least include what nature is doing simply.

Complex systems display nature's way of making complicated things simple. In figure 1 the most important thing to notice is that the curves move together. It shows that they reflect proportionally constant parts of one system that is working steadily and smoothly as a whole. It's actually the smoothness of the curves that is most telling. The hypothesis is that the smoothness of the curves is evidence of the system efficiently equalizing stresses between its parts as they respond to each other, like in a fluid. This is also supported when looking closely at the small fluctuations discussed below in relation to Figure 2. It indicates that the system consistently allocates energy resources to its various parts in response to their improving productivity, having what I call "ESP" (or "equal stress principle"). The regularity of the curves displays the system, until 2006 at least, working as a single coordinated process.

This is also supported by how the whole system integrates the surprising irregularity in these same metrics for the separate national economic accounts. Recent studies of individual national economic accounts show widely varying movements in GDP and efficiency (Hall, 2007; Gupta, 2009). The smooth regularity of the global data shows that the local variations compensate for each other. The plausible reason is that the world market mechanism is being efficient in allocating its resources to optimize the growth of the whole. Having a system of parts that move in complementary ways, like waking smoothly with alternating steps, is one of the things it means to be "part of a system".

For energy use and GDP at least, it shows that every part of the world economy is responsive to every other part in working as a whole. That suddenly makes the world economy appear to be organized and behaving more like an individual organism than the chaotic tangle of conflicting directions of change one hears about in the news. That evidence of simplicity arising from confusion is the same effect seen when looking inside a living organism to see how it works. All you ever see is a somewhat bewildering complexity and little hint of how it is that nature makes it work together with singular purpose.

Still, despite most approaches to this subject not asking the question from a view of the economy as a whole, it does seem odd that the main reason businesses struggle to be more efficient would be overlooked on such an important question. That businesses use efficiency to increase sales seems fairly obvious. Its effect on resource depletion was first well described by Stanley Jevons 145 years ago (Jevons 1865).

Even then people were hoping efficiency would extend England's coal resources, and so it was called "Jevons' Paradox". The idea that efficiency might somehow have a resource use constraint effect without a stimulus effect has haunted the whole discussion ever since. Some recent authors such as Greenhalgh (1990), Hall (2004, 2007), Alcott (2005), Polimeni et al. (2008), Madlenera and Alcot (2009) and Henshaw (2009) describe efficiency as a growth stimulus, concurring with Jevons' first observation. In a world where the public, policy makers and other scientists hold the "pervasive assumption" that efficiency can act as a constraint without a stimulus effect (Tainter, 2008) even these authors have mostly found it necessary to speak of it as an open question.

This sort of consistent pattern of widely popular denial of the main direct purpose and effect of something seems to point a genuine cognitive gap in our thinking. It appears that for 145 years both our economic planners and environmental protectors have overlooked a rather obvious reason for the clear evidence. Now we find ourselves relying on a strategy to "save the planet" from critical resource depletion, using a method that appears to have always had the opposite effect. It's surely troubling. It's also possibly a very interesting discovery, potentially indicating that other new understandings of the problem might follow.

What it seems sincere people are missing

The normal business use of efficiency to leverage expanding production, sales and profits, is called "productivity". If you look at the units and what is measured, "efficiency" and "productivity" measure the same thing, material returns on investment. They may be measured in different places in the business system, but the main difference is that one measures the upstream cost reduction effect (use less) and the other the downstream increased returns effect (get more). We seem to have two words for it because one is used when thinking about reducing costs and the other when thinking about increasing returns. The blind spot appears to be not mentally combining the two thoughts.

Efficiency per se is not the real culprit of course, but understanding how we use it. Presently we select efficiencies for giving us the greatest downstream benefit of increased productivity for growth and profits. If Jevons had called it the "productivity effect of efficiency" it might never have seemed like a paradox. The environmental movement has stayed focused on the cost reduction effects and ignored the productivity effects, though. That selective reasoning has been a regular selling point to the business and finance community who have supported it. As a policy it serves to continually increase our remote control and accelerate our use of natural resources and systems. It expands our access to the resources we're depleting while giving us an impression of expanding them, but doesn't actually create any.

It's hard to avoid wondering here whether the real reason we ignore the larger scale increasing impacts of enhanced productivity is that productivity improvements are so profitable. It looks like environmentalists are ignoring their multiplying impacts for the profits created by it just the same way they complain about business ignoring their multiplying impacts for profits. It makes the profits much more attractive to think of them as not having any impacts, all around, of course. That's certainly seems reinforced in our culture, too, to casually “look the other way” if you’re making money on the deal.

That bias for profit might contribute, but the main reason for ignoring the large scale resource impacts of increased productivity appears to be that they occur on a different scale of organization in the economic system. They don’t occur within the operations of the business unit or home economy that people are personally familiar with and motivated to streamline for reducing the environmental impacts they see themselves as causing. They occur beyond that “domain of control”. The larger scale impacts occur by the “invisible hand” of the marketplace as consumers rush to your sales outlets to buy your improved and less expensive products. That creates higher sales and profits so the business and its investors so can all expand your and their own and other businesses. The implication is that to understand the effect of sustainability policies one needs to understand how the system and all its levels of organization respond as a whole.

Tracing how reductions in one place become increases in others is not really practical unless you can find some natural boundary and make a meaningful whole system budget for it. One method of doing that for an individual business operation is the SEA (system energy assessment) method demonstrated for measuring EROI for an energy technology business operating a wind farm (King, 2010). That method relies on identifying the whole operating system of parts a business needs for producing a given product. It uses that natural boundary to calibrate the measure of whole system energy use. One might do the same for your whole home economy, defined as working unit to understand how one change would effect the total. As much help as it is to understand what is happening within an individual whole business unit or home economy, it doesn't tell you how it is linked with other scales of organization in the larger system. That seems to be the real reason for why we end up using stimulus as a constraint. We only know our local working units of the larger system, and are mostly unaware of the economy's other scales of organization.

The same general analytical solution can apply though. Finding a natural boundary lets you use the conservation of energy to account for energy use for the system as a whole, if you can find the boundaries. The usual way we define the boundary of what is connected in the world is as the limits of our own understanding. That places us in the center of the system and includes everything we see as connected through our information. To identify the separate natural boundaries of individual systems, though, you look for the extent of their own internal networks of organization. That's picking out systems as defined by a common language, technology, culture or other things you could consider as a whole cell of organization. Sometimes the starting point for identifying them is finding some of their reciprocating parts. Also useful is that most things that display trends of progressive growth or maturation are part of a local network of processes that are developing as a whole, and that behavioral tag helps to identify their working processes and boundaries.

Most sincere people trying to do what they can to live in peace with the earth have never even considered the above as an issue I expect, but it's part of how natural complex systems are organized. Our bodies are the same way. We have lots of organelles within each cell, lots of cells within each organ, and lots of organs in a body. Our bodies need to be part of a community, within a species, within an ecology, on a living planet. Our general familiarity with that idea developed only in the last 50 years I think. A basic appreciation of how these levels of independently changing organization in natural systems work and communicate may take another 50 years. It's just not familiar territory. It's an exploration.

The real price to pay for letting this oversight continue, though, is that it encouraged people to have faith in a strategy that clearly could never work. That also kept them satisfied that they had a solution and prevented them from looking beyond seemingly easy answers for what actually would work. If we realized that improving efficiency in no way changes the economic system to keep it from continually multiplying our environmental impacts, then we'd need to ask what would.

The fine detail

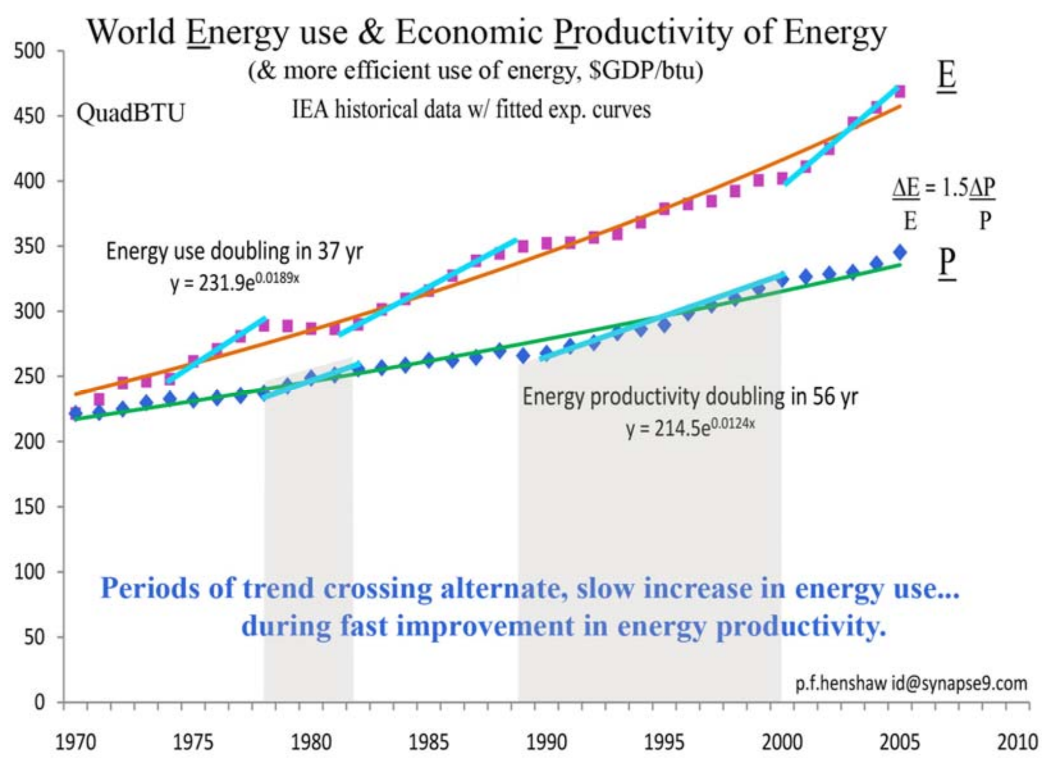


Figure 2 - Alternating periods of faster world energy use and efficiency gains.
[Same data as Fig. 1, presented with Energy Efficiency/Productivity indexed to 1971 value of Energy Use]

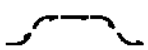
Another indication of active coordination between efficiency improvement and economic growth is the regular alternation between periods of faster rising energy use and faster improving energy efficiency. As seen in Figure 2 they go back and forth as if taking alternating steps in one process. The small scale waves in energy use are 180° out of phase with those of efficiency improvement, as if part of the same process.

One plausible reason for it has to do with what causes normal recessions. The evidence is that increasing energy use slows when efficiency improvements accelerate and the reverse. That would be quite logical if pauses in growth were times when inefficient parts of the economy were replaced by more efficient ones, and periods of faster growth when businesses were too busy to make changes. In that "creative destruction" process, occasionally pausing to reorganize and retool for faster growth makes sense as a response to running into local limits to growth. So each period of slowing growth in energy use might be seen as a time of reorganizing the economy to be efficient for its new environment, and allowing the next little growth spurt. It adds to the impression of close coordination between increases in GDP, efficiency and energy use. Seeing it as working by a stepwise learning and reorganizing process could either be taken to suggest there are no growth limits, or that learning is constantly running into limits.

Balancing the energy budgets of change

It seems our ancient "hunter-gatherer" thinking does not distinguish between increasing our access to things and increasing the things to be accessed. That mental error turns up in lots of places, like the belief that continually finding new ways to substitute for resources used in the past makes the earth infinite and allows continually more rapid growth and new resources. That error is sometimes avoided if you can represent resources as stocks and flows in a mathematical model. Then addition one place is recognized as subtraction in another. For learning processes that's not as easy, except that every learning process does still have an energy budget! If you can identify systems as a whole of any kind you can set up the basic energy conservation equation, as a tool for exploring the system before you have a model. You just need to have a boundary and balance the energy entering and leaving.

One way nature makes complex systems work simply as a whole can be seen in the common narrative of continuous change they display, from small beginnings to small ends, involving growth and decay. Things that use energy take time to assemble and operate the internal processes that do it, taking in and then releasing energy as they develop their mechanisms which later decay. Following the swelling and fading of energy flows for systems is like "follow the money" for detective work. It helps identify the assembly of working parts involved. It serves to define a boundary for the system too, for which one can then outline the rudimentary energy budget. Within the system you need positive net energy, more "energy producing" than "energy consuming" processes. For the whole system you need to satisfy the basic laws of energy, the conservation of energy, the internal costs of system development, products and losses.. You know that before knowing how any part works. It's a way to convert a simple observation of eventfulness in your environment into a map for carefully examining the necessary working parts of the processes doing it.



$$\Rightarrow \qquad E_{in} = E_{devl} + E_{oper} + E_{loss} \quad \& \quad E_{devl} > E_{oper} \qquad (3)$$

Complex systems develop as individual things, not as duplicates of a class of things, but that does not free them of the laws of physics such as energy conservation or the 2^{nd} law principle that it wastes energy to use it. In an energy budget for a temporary energy using system being built from scratch, one needs to include the energy used to build and later dismantle the system, E_{devl} as in Equation 1, equivalent to "venture capital" that any business needs as much as any animal needs its egg or plant needs its seed. The three types of energy uses define a basic map for exploring a complex system life cycle. Accounting for the implied functions points to gaps in your information you can probably fill with some effort, starting with only what's necessary for energy uses to begin and end.

It sounds rough but helps frame the inclusive questions needed. That's what's needed different information does not shown the system going in opposite directions, and you know which direction the net result is in. For energy one can use the average btu/$ estimate if no better measure is available so one can at least define the real problem. Then the trends and rates of changing trends tell you when the tasks are getting easier or harder and imply local limits of efficiency due to entropy and ask what matching responses are available.

Other cases of using stimulus for constraint

One of our resource consuming "growth centers" is healthcare, where because we are mortal curing incurable diseases tends to give us even more expensive incurable diseases. It's not that healthcare is '*wrong*' but that our economic model for profiting ever more from it is not a solution for our desire to live as well and as long as we can. Our economic approach rewards the solutions that increase the problem to be solved. That would inevitably have gotten to a point of making the energy conservation equation for healthcare ever more out of balance, consuming ever more and generating ever less at compound rates. Making healthcare profitable stimulates more need for healthcare in the name of reducing it, using stimulus as constraint.

Our approach to global warming works this way too, following a similar economic model. The plan is to respond to the irreversible environmental impacts of the past, but uses a method of doing so that assures larger irreversible impacts in the future. We plan to use profitable science and financing to grow the economy and convert nearly all our energy systems to zero carbon technology. Global warming does seem to be an exceptionally dangerous irreversible process if allowed to continue. Due to the rapid societal and technological changes required to respond to it at scale, it also seems quite legitimately to call for a "wartime speed of response" as many scientists describe (Brown 2008, IPCC 2007).

The puzzle is that these and nearly all other far reaching proposals for doing it call for stimulating economic growth with profitable efficiencies as a method of reducing our resource use and impacts, as a way to make setting hard limits on target pollutants affordable. It proposes to keep doubling the scale of the economy as if it couldn't cause a problem, to correct the errors made fifty and a hundred years ago to continually double the scale of the economy as if it couldn't cause a problem. However risky the engineering and economics of mitigating global warming is, the bigger problem would come from its success. Even if the seemingly improbable technology solutions were to work perfectly for the impacts of the past, it assures that the spectrum of continually doubling impacts of growth would continue unabated. That's not solving the problem but creating more unmanageable ones.

If you believe the conservation of energy is a valid explanatory principle, the future impacts of growing energy use would be "at scale" and so proportionately bigger than the present ones. So our plan for responding to growth impacts includes solving them with continually multiplying growth impacts. Some of those next more costly and more unmanageable impacts can now be seen emerging. Having turned the corner from finding expanding to shrinking resources, one impact of growth is the increasing competition over shrinking rather than expanding resources. That naturally results in world of increasingly intense conflict rather than plenty.

Discussion

The most scientifically interesting aspect of how we have been confidently misinterpreting how the world works is that apparently the world does work. It just works on its own, though, and in a way significantly unlike the many different ways we have been explaining it to ourselves. We can also begin to see that nature appears to have individual whole systems that have somewhat explorable organization independent of our explanations. That nature seems to have a way of working we don't understand seems obvious. It adds to the puzzle that the sciences largely represent nature in terms of their own theories. If each science defines nature as its own separately constructed theory it might explain why they often don't connect with each other and can not speak to the cultural terms of other discussions. Maybe it suggests a need to go back to basics.

The original question of science "I wonder how that works?" was quite undefined. It sometimes worked, though. So, maybe everyone's idea that nature works according to their own explanation hides how each explanation could still be valid, but unable to connect as a individual perspectives on the same subject. The old

Buddhist fable about that concerns a proverbial “elephant” and six blind men called upon to describe it to the king. They find themselves unable to mentally connect their descriptions of the different body parts they can touch. Each description is mostly valid except for being unable to recognize or interpret each other’s. Their obvious next task would be to look for what connects each part of the whole, to fill the information in the gaps between their different languages.

Using a global energy budget is how I discovered several of these interesting departures from reality. The budget used was elementally simple. It was based on the necessity that the total energy should equal the sum of average values for all the parts. I used the average energy use per dollar of GDP, now around 6000btu/$ worldwide. I compared the energy use estimates made for various products and projects to the average energy use for their cost. The estimates made by others varied from 50% to 90% below average (Henshaw 2007). One of the first rules of statistics is that not everyone’s performance can be far above or below average.

Then I looked at the world energy use data shown in Figures 1 and 2 and asked how efficiency and energy use trends would need to change to result in decreasing impacts as needed. That immediately showed how improbable that would be (Figure 3). To reduce impacts with improving productivity you would need to make energy use so much more valuable all the time that we continually used ever less of it! It sounds like a complete fantasy, surely for our present economic culture.

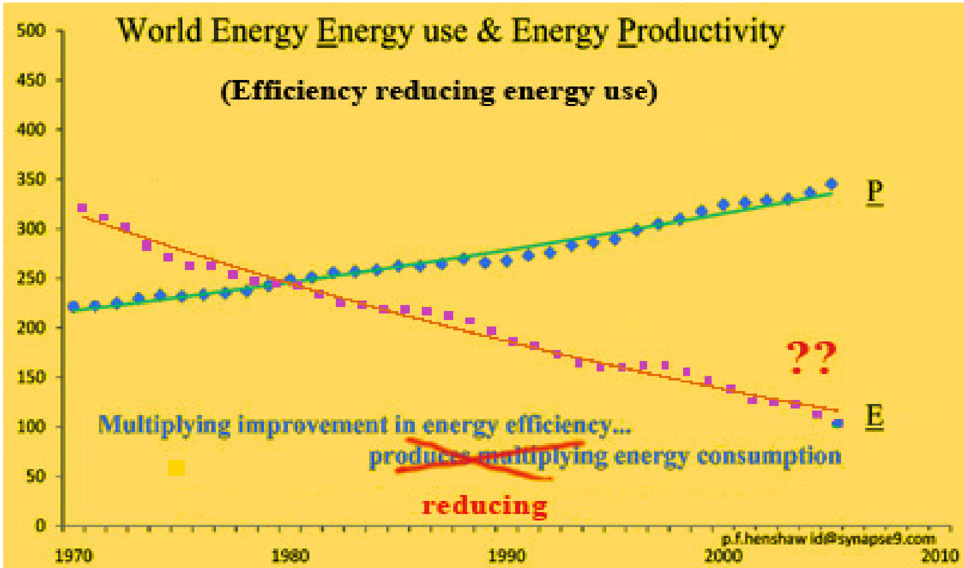


Figure 3. Instead of energy use increasing, could we have productivity make energy use decline? [On top is same data as Fig. 2, and below energy use is turned around to show ever declining need for resources to produce growing wealth, as the "absolute decoupling" idea assumes]

As far as I know this world energy budget approach has not yet been part of the reasoning behind resource conservation policies, and no one has been actually adding up the totals. I don't know all the literature or policy studies, of course, but the popular ones clearly don't seem to. I think the main objective has always seemed to only be "let's do our best", assuming that efficiency would be the best way to do it, and not "let's add up the total". There are even quite sophisticated models of world energy technology choices integrated with economic models (Argonne 2008). These only seem used to help industrialists see which investments are going to be the most profitable. That facilitates the efficiency of allocating resources, but it doesn't save energy, create resources or balance the conservation equation. It creates ways to meet the projected energy demand, not to to limit the explosion of impacts of energy uses.

We seem to need to go back to basics to better understand complex systems that we won't ever have formulas for. That suggests wondering what changes in the scientific method would help. The basic question of science is not: "What are the logical implications of the rules we hope nature is following?" or even "What rules can I find in my data?" After "I wonder how that works?" comes "What can I say with confidence when I realize I don't know much?" That seems to be what Newton and Copernicus asked. One thing you can discover about natural systems and know with confidence is that some can be identified as working as a whole. That makes them somewhat explorable and to have identifiable boundaries with outside connections for which basic energy budgets necessarily need to add up.

For sustaining complex societies on earth most of the world is using a method of conserving the resources needed that increases their availability at the cost of increasing their rate of depletion. That does indicate major rethinking is in order. It would take time and explorations that are not predetermined in their outcome. It would take a developmental process starting with small steps. The tool we seem to need most for connecting our disconnected languages for the problem at hand seems to lie in the gaps between them. What would help is recognizing the natural organization in the social and economic systems we are part of, and are trying to change. We could make those our common subject and connector for the discussion. Then everyone's different way of explaining them would become naturally connected and potentially useful to each other.

Being curious about small things that others leave unexplained, and seem to expect you to brush off without thinking too, is another part of how this group of problems was discovered. For many years, myself included, we have all been betting our whole future on reducing our impacts on the earth using a long discredited but popular method that multiplied them. We just ignored one of the more obvious accumulative effects of our own quest for a better life. Realizing that efficiency improvements have two effects, letting you use less of one thing usually to have more use of others, says you are working within a system. It has both upstream and downstream effects. The larger consequences now come from the "invisible hand" of responses from market environments downstream. As in crossing a street you should always look both ways. For the effect of individual choices it's partly a matter of looking back and forth within the boundary of a local system of interacting choices for a way to estimate its total. It also means looking up and down toward other scales of natural organization. It's upsetting to recognize that we haven't been doing that. It's also hopeful for exposing new understanding of our real choices. Without suspending our disbelief and looking beyond our usual limits we can't know what we'd find, of course, so we'd have to go and look. It would be worth the trouble if it turns out that these gaps in our understand hold worlds of opportunity we've been missing.

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