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Energy efficiency flawed due to rebound effects

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This is a guest post by Cameron Murray, an Australian economist who currently works for a regulatory authority. Cameron has a blog that he calls Observations of an Economist Environmentalist.

The word *efficiency* carries a meaning immersed in all things positive – you never hear that being more efficient could possibly be detrimental. In fact, if you can bear the evangelical fervour, you may have read about achieving 'Factor Four' or 'Factor Five' gains in energy efficiency, as part of a 'Natural Capital' revolution comprising a 'decoupling' economic growth from a growth in the consumption of exhaustible resources – also known as 'sustainability'. You may even have heard about the equation I=PAT or I = P x A x T, where environmental impact (I) is a function of population (P), affluence (A) and technology (T), and that becoming more efficient will enable a desired level of affluence with far less environmental cost.

Historical experience shows that these claims are untrue, and indeed the facts suggest greater energy efficiency is counterproductive to the stated aims of curbing resource use and decreasing negative environmental externalities.

When it comes to natural resource use, and the externalities associated with resource extraction and production, efficiency alone is the ***enabler of greater consumption***. William Stanley Jevons first noted that technological improvement, in terms of greater efficiency and therefore productivity, was the enabler of greater coal consumption in Britain back in 1865 in his book, The Coal Question: an Inquiry Concerning the Progress of the Nation, and the Probable Exhaustion of our Coal-mines. His observation was coined Jevons Paradox, even though the argument that technological improvements in resource efficiency (modes of economy) leads to greater resource use was already widely accepted in the labour market:

> "As a rule, new modes of economy will lead to an increase in consumption according to a principle recognised in many parallel instances. The economy of labor effected by the introduction of new machinery throws labourers out of employment for the moment. But such is the increased demand for the cheapened products, that eventually the sphere of employment is greatly widened."

One hundred and fifty years later, the modern debate is fuelled by economic ignorance, with many of the most influential economists and environmentalists remaining confused - failing to acknowledge the parallel effects of technology on the resource called 'labour' and other resource inputs to the economy.

More rigorous economists have reopened the debate, under the new term rebound effect, breaking down the transition mechanisms between greater efficiency and greater resource consumption.

1. Direct rebound effect: Increased fuel efficiency lowers the cost of consumption, and hence increases the consumption of that good because of the substitution effect.
2. Indirect rebound effect: Through the income effect, decreased cost of the good enables increased household consumption of other goods and services, increasing the consumption of the resource embodied in those goods and services.
3. Economy wide effects: New technology creates new production possibilities and increases economic growth.

UCLA mathematics professor Terence Tao explains the direct effect as follows:

> Suppose one has to decide whether to use one light bulb or two light bulbs to light a room. Ignoring energy costs (and the initial cost of purchasing the bulbs), let's say that lighting a room with one light bulb will provide $10/month of utility to the room owner, whereas lighting with two light bulbs will provide $15/month of utility. (Like most goods, the utility from lighting tends to obey a law of diminishing returns.)
>
> Let us first suppose that the energy cost of a light bulb is $6/month. Then the net utility per month becomes $4 for one light bulb and $3 for two light bulbs, so the rational choice would be to use one light bulb, for a net energy cost of $6/month.
>
> Now suppose that, thanks to advances in energy efficiency, the energy cost of a light bulb drops to $4/month. Then the net utility becomes $6/month for one light bulb and $7/month for two light bulbs; so it is now rational to switch to two light bulbs. But by doing so, the net energy cost jumps up to $8/month.
>
> So is a gain in energy efficiency good for the environment in this case? It depends on how one measures it. In the first scenario, there was less energy used (the equivalent of $6/month), but also there was less net utility obtained ($4/month in this case). In the second scenario, more energy was used ($8/month). But more net utility was obtained as a consequence ($7/month). As a consequence of energy efficiency gains, the energy cost per capita increased (from $6/month to $8/month); but the energy cost per unit of utility decreased (from 6/4 = 1.5 to 8/7 ~ 1.14).

The indirect effect is more subtle and it is the environmental cost of consumption of other goods due to costs saved on, for example, lighting. If, in the above example, lighting costs were reduced to $2 per bulb for the room, it would be rational to spend $4 on lighting (using two bulbs) and spend the $2 saved on lighting to consume other goods which themselves have energy use embodied in their production.

Finally, the economy wide effect occurs due to stimulated demand for other goods and efficiency gains being shared across other sectors (due to the principle of the indivisibility of economic productivity – the linked article is highly recommended).

These economy wide effects have gained recent attention in The Economist where it is estimated that energy efficient lighting will contribute to greater energy use in the long run. You will note from the comments, the cognitive dissonance of economists when referring to labour and other resource inputs remains.

Conservation, using less at a given level of technology by giving up some utility, is equally ineffective (also highly recommended). We still face the indirect effects from conservation as we spend elsewhere in the economy, and if you believe all consumption has equal environmental cost per dollar (due to indivisibility once more and conceptual boundary problems to traditional input-output analysis of embodied resources), then you are back to where you started.

Further, conservation, like waste, is a relative concept, and by definition we can't all do it. And we wouldn't do it either due to the tragedy of the commons problem, where it is in each person's best interest to defect from a cooperative conservation strategy. Terence Tao once again explains:

> However, if there are enough private citizens sharing the same resource, then the "tragedy of the commons" effect kicks in. Suppose for instance that there are 100 citizens sharing the same energy resource, which is worth $1200 x 100 = $120,000 units of energy. If all the citizens conserve, then the resource lasts for $120,000/$400 = 300 months and everyone obtains $1800 long-term utility. But then if one of the citizens "defects" by using two light bulbs, driving up the net monthly energy cost from $400 to $404, then the resource now only lasts for $120,000/$404 ~ 297 months; the defecting citizen now gains ~ $7 x 297 = $2079 utility, while the remaining conserving citizens' utility drops from $1800 to $6 x 297 = $1782. Thus we see that **it is in each citizen's long-term interest (and not merely short-term interest) to defect; and indeed if one continues this process one can see that one ends up in the situation in which all citizens defect. Thus we see that the tragedy of the commons effectively replaces long-term incentives with short-term ones, and the effects of voluntary conservation are not equivalent to the compulsory effects caused by government policy.** (Emphasis added)

If energy efficiency is a counterproductive action for our environment, and personal conservation is useless, what should be done? As renowned ecological economist Blake Alcott points out:

> If Jevons is right, efficiency policies are counter-productive, and business-as-usual efficiency gains must be compensated for with physical caps like quotas or rationing.

It really is that easy. If you are concerned about greenhouse gases, a cap on greenhouse gases is what is required. If you are worried about deforestation, you create a cap by 'fencing off' areas that are not be touched. If you are worried about over-fishing, you create a cap. Whether these caps/quotas are tradeable is a secondary concern, but making the caps tradeable does enable the cap to be met most efficiently.

What about a tax instead?

Many commentators argue that taxing negative externalities (such as a carbon tax) would not only reduce greenhouse gas emissions, but would also provide a 'double dividend' of improved economic efficiency because taxes which create other economic distortions could be reduced.

However, the very nature of reducing other taxes to ensure revenue neutrality would mean that other sectors of the economy with a reduced tax burden now have greater purchasing power to pay for those goods subject to the new tax. Thus the double dividend comes at a cost to the primary dividend of reducing externalities.

Politics and ideology probably explain why the most basic economics is tossed out the window when it comes to the environmental protection. Then again, maybe we just can't acknowledge that such a thing of beauty – efficiency - could possibly have a downside.