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Can we decouple energy consumption from economic growth?

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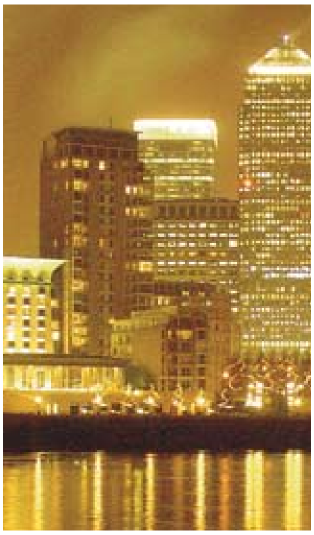

Capitalist economies are structurally dependent upon continued economic growth. But economic activity requires energy, largely sourced from depleting fossil fuels with associated carbon emissions. In the face of growing concerns about energy security and climate change, this raises some difficult policy questions. Is it possible to reduce the amount of energy used per unit of GDP – or to "decouple" economic growth from energy consumption? Can we sustain economic growth while at the same time radically reducing energy consumption and carbon emissions? If not, is continued economic growth sustainable? This Policy Brief shows how economists disagree about the potential for decoupling, links this to the opposing worldviews of orthodox and ecological economics and highlights some important policy implication.

Key messages

- Economists disagree about the extent to which it is possible to decouple energy consumption from economic growth. This division hinges in part on the different worldviews of orthodox and ecological economists.
- Orthodox economics is inconsistent with basic physical laws and assumes that energy plays only a minor role in economic growth. In contrast, ecological economics better reflects those laws and attributes a key role to energy.
- Orthodox economics assumes that the rebound effects from energy efficiency improvements are small and that decoupling is both feasible and relatively cheap. In contrast, ecological economics suggests that rebound effects can be large and that decoupling is both difficult and expensive.
- At present, there is insufficient evidence to demonstrate which perspective is correct. Only limited decoupling has been achieved to date and the causes of this decoupling remain unclear. But the ecological perspective highlights some important blind spots in conventional thinking that deserve much closer attention. It also emphasises the importance of contemporary work on "steady state economies".

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Two opposing economic worldviews

Orthodox and ecological economists disagree about the extent to which energy has been decoupled from economic growth, the causes of that decoupling and the potential for further decoupling. Orthodox economic models imply the economy is a closed system within which goods are produced by capital and labour and exchanged between consumers and firms. While such models can be extended to include natural resources, ecosystem services and wastes, these remain secondary concerns at best. Economic growth is assumed to derive from a combination of increased capital and labour inputs, changes in the quality of those inputs (e.g. better educated workers) and technical change. Energy is assumed to make only a minor contribution to productivity improvements and economic growth, largely because it accounts for only a small share of total costs. It is also assumed that capital and labour can substitute for energy should it become more expensive. From this perspective there is no reason why energy consumption could not be substantially decoupled from economic growth.

Ecological economists argue that orthodox models ignore how the economy is embedded within the global ecosystem. In their view, economic activity is sustained by flows of high quality energy and materials which are then returned to the environment in the form of wastes and low temperature heat. The system is driven by solar energy, both directly and embodied in fossil fuels, and since energy cannot be produced or recycled it forms the primary input into economic production. In contrast, labour and capital represent intermediate inputs since they cannot be produced or maintained without energy. So far from being a secondary concern, energy becomes the main focus of attention.

Orthodox economics is inconsistent with basic physical laws.

Energy carriers differ in terms of their cleanliness, flexibility, energy density, ease of storage, thermodynamic characteristics and economic productivity. For example, electricity represents a 'higher quality' form of energy than coal. Ecological economists claim that improvements in economic productivity over the last century have largely been achieved by providing workers with increasing quantities of high quality energy, both directly and indirectly as embodied in capital equipment and technology. This has been demonstrated empirically in relation to the claimed decoupling of energy consumption from GDP: once energy quality is accounted for, very little decoupling is observed. Ecological economists argue that the increased availability of high quality energy has facilitated technical change, enhanced the productivity of capital and labour and allowed more economic output to be produced for each unit of energy input. Hence, the contribution of energy to productivity improvements and economic growth may be greater than suggested by its share of total costs.

Ecological economists also claim that the *indirect* energy consumption associated with capital and labour (e.g. the energy required to manufacture thermal insulation) limits the extent to which they can substitute for energy in economic production. Not only is this indirect energy consumption poorly reflected within orthodox models, such models also violate the second law of thermodynamics. Hence, from the ecological perspective, the potential for decoupling energy consumption from economic growth is more limited.

This perspective also raises questions about decoupling achievable by shifting to a service-based economy. Such shifts may sometimes increase energy use, particularly if the services involve extensive transport use (e.g. home deliveries of internet shopping or take-away meals) or require energy-intensive infrastructure such as telecommunications networks. Recent reviews have shown that the environmental benefits of such shifts are relatively modest since most services are heavily reliant upon manufactured commodities. Furthermore, the potential for global decoupling is constrained by the fact that shifts to a service-based economy in developed countries have largely been achieved by outsourcing manufacturing to developing countries. For example, net exports from China account for some 23% its carbon emissions and once aviation, shipping and the carbon embodied in traded goods is taken into account, UK carbon emissions are found to have increased since 1990.

Ecological economics suggests the potential for decoupling is limited.

Rebound effects and decoupling

The potential for decoupling may be further limited by the 'rebound effects' from energy efficiency improvements. For example, a driver may take advantage of the cheaper running costs of a fuel-efficient car to drive further and more often. Alternatively, she may put the cost savings towards an overseas holiday and thereby increase energy consumption elsewhere in the economy. In some cases, these effects could be sufficiently large to lead to an overall *increase* in energy consumption. This possibility was first recognised in the 19th century, when improvements in the energy efficiency of steam turbines were found to lead to more coal being consumed. Energy efficient turbines were adopted in a wide range of industries and their application to coal mining and steel manufacturing led to positive feedbacks that further expanded the market for coal. Similar patterns have since been observed with other 'general-purpose technologies' such as electric motors, lighting and computing. Over time, such technologies can lead to revolutionary changes in industrial processes, technical infrastructures, consumer products and lifestyles. While improvements in such technologies frequently reduce energy consumption per unit of economic output, they also boost overall productivity and output to such an extent that aggregate energy consumption increases.

These effects may explain why reductions in the energy intensity of economies are almost universally accompanied by rising energy consumption. The causal links are complex, but ecological economists such as Robert Ayres have developed alternative models of economic growth which partly explain this phenomenon. These models reproduce historical trends in economic growth extremely well, without attributing any role to technical change. Instead, a key driver of economic activity is the 'physical work' obtained from the conversion of energy – which may either be increased by using more or higher quality energy or by improving energy efficiency. In these models, the productivity of energy is around ten times greater than its share of costs, implying that efficiency improvements could dramatically increase economic output. This in turn could increase rather than reduce energy consumption.

Conclusion

Orthodox economics assumes that energy makes only a small contribution to economic growth, rebound effects are relatively small and decoupling is both feasible and relatively cheap. In contrast, ecological economics suggests that energy plays a key role in economic growth, rebound effects are relatively large and decoupling is both difficult and expensive. At present, there is insufficient evidence to demonstrate which perspective is correct. But the ecological perspective highlights some important blind spots within orthodox theory that are reflected in the assumptions and design of the economic models used to inform climate policy. Continued reliance upon such models may therefore lead to falsely reassuring estimates of the potential for decoupling and of the cost of reducing carbon emissions. This raises some fundamental questions about the long-term sustainability of economic growth given the constraints imposed by resource depletion and climate change. It also highlights the importance of contemporary work on 'steady state economies' by bodies such as the Sustainable Development Commission.

The sustainability of economic growth in the long term deserves to be questioned.

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