

Capital costs: Research offers truer calculation of 'footprint' of purchases

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Credit: Anna Nekrashevich from Pexels

If one wants to calculate the environmental impact of purchasing a product or services, they must consider the role of the capital assets that went into their production—machinery, factories, IT, vehicles, and

roads—and the energy and materials required to create those assets. For instance, any assessment of the environmental "footprint" of renting a home should include the materials and processes that went into its construction.

However, many of the models used to assess the impacts of purchases—known as "environmentally extended input-output" (EEIO) analyses—don't incorporate data that would account for the contributions of these capital assets. As a result, most analyses underestimate the carbon, energy, and material footprints.

In order to get a more accurate estimate, Yale researchers have developed a new model using the most recent detailed economic data available, from the years 2007 and 2012. The model incorporates those capital assets into the production supply chains, providing a more comprehensive understanding of the environmental impacts associated with a range of sectors, from mining to government to media.

According to their analysis, use of capital assets for production in 2012 accounted for 13 percent, 19 percent, and 40 percent of the economy-wide carbon, energy, and material footprints, respectively.

"For some products—such as recorded music, medical instruments, or communication devices—the impacts of capital assets used actually outweigh those related to direct material and energy inputs to production," said Peter Berrill, a Ph.D. candidate at the Yale School of Forestry & Environmental Studies (F&ES) and one of the developers of the model. "So if you're not incorporating that data you're missing the full extent of the [environmental impact](#)."

The findings are published in the *Journal of Industrial Ecology*.

By combining supply-chain data on a range of products and services with

industry-level emissions data, EEIO models reveal important insights into the life cycle environmental impacts of a particular product—or any group of products. But since EEIO models use data from trade between companies in services and consumable inputs, long-lived capital assets are usually omitted. For the new model, the researchers developed a highly detailed capital flow matrix approach to incorporate the role of capital assets. In addition to including such assets as machinery, vehicles, and buildings, the model incorporates "knowledge capital" such as technologies and patents that emerge from research and development.

According to their findings, the products most affected by capital, in terms of overall economy-wide carbon footprint, are housing, government services, gasoline production, and healthcare. Construction assets, as expected, are key contributors to the housing sector. Metals, vehicles, and machinery are critical components for such sectors as federal defense.

Meanwhile, research is a major contributor in the case of federal government and pharmaceutical sectors. "For pharmaceuticals, you need to have done research in the past to develop and produce drugs," said Berrill. "And that research may have been very environmentally intensive."

As part of this effort, the authors also developed a spreadsheet-based tool that allows users to quickly estimate carbon, energy, and material footprints associated with purchase of more than 400 products and services that drive the U.S. economy.

This tool will be useful to researchers and students as well as organizations looking to reduce their environmental impacts.

"It allows those involved in a purchasing or producing a particular good to get a better sense of, say, how much a thousand dollars spent on that

good compares on average environmentally with a thousand dollars spent on another," said Reed Miller, a Ph.D. candidate in the Yale School of Engineering and Applied Science and co-developer of the [model](#). "It also enables one to identify the potential 'hotspots' they might want to focus on if they want to reduce their footprints."

"If you're targeting efforts to reduce the impact of something and you're not considering the capital aspects, then you might miss opportunities for improvements."

More information: Peter Berrill et al, Capital in the American carbon, energy, and material footprint , *Journal of Industrial Ecology* (2019).
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