The Shadow Impact Calculator and Divestment: Data and Model Limitations

A contribution by Alastair Fraser[i]

The fossil fuel divestment movement has spurred significant debate on the political, economic, and environmental rationale for divesting. Contributing to this important discussion is recent research proposing a method for quantifying the environmental impact of investments and applying it to the University of British Columbia's endowment.

The concept of a "shadow impact calculator" (SIC) is developed in the pair of papers "Understanding the shadow impacts of investment and divestment decisions: Adapting economic input–output models to calculate biophysical factors of financial returns" published in *Ecological Economics* [ii] and the Pacific Institute for Climate Solutions (PICS) white paper, "*Fossil Fuel Divestment: Reviewing Arguments, Implications & Policy Opportunities*"[iii], both by Justin Ritchie and Hadi Dowlatabadi.

Ritchie and Dowlatabadi use the SIC to examine the impact of fossil fuel divestment on the "carbon shadow" of UBC's endowment. While developing methods for quantifying the environmental impact of investments may be important, the above papers and the SIC method contain several limitations that may not be apparent to a casual reader. Ritchie and Dowlatabadi acknowledge a number of these limitations in their work, however I wish to highlight them further as they may be important for both proponents and opponents of divestment to consider.

There are four primary limitations to Ritchie and Dowlatabadi's analysis. First, unintended outliers in the data largely drive their findings. Second, the carbon shadow should not be viewed as similar to a carbon footprint. Third, the carbon shadow is highly sensitive to financial performance and additionally should not be used to inform investment choices between companies within an industry. Lastly, the SIC relies on past greenhouse gas (GHG) emissions intensities and single-year snapshots of the economy (among other assumptions), which necessarily renders it of limited use in drawing conclusions about the future impact of investment decisions. In particular the SIC is unable to address investment decisions seeking to reduce greenhouse gas emissions through changes in how energy is generated.

1) The carbon shadow impact of divestment is understated due to a reliance on an outlier sample of alternative energy firms.

Ritchie and Dowlatabadi examine the impact of divestment on the carbon shadow of UBC's endowment by replacing six current fossil fuel investments with investments of a comparable value in six randomly chosen alternative energy companies. However the authors' sample, chosen by a random number generator, turns out to be a significant outlier from the industry average. As a result their conclusions significantly understate the expected carbon shadow impact of this divestment scenario. In fact, using industry averages instead of their subsample of 6 companies[iv], the SIC method yields carbon shadow reductions of 90%, rather than the 22% in the white paper divestment scenario.

The six alternative energy companies in *Divestment Scenario One (*Table 1 of the PICS report*)* are not representative of their industrial sectors. 67% of the alternate investment carbon shadow is due to a single solar company with a small market capitalization, China Sunergy, and the carbon shadows vary from 10 to 4,000 tCO2e/mn$inv among the six companies chosen. This magnitude of impact from a single company and range of carbon shadows immediately highlights the importance of outliers in the data.

Industrial sectors' average performance is more appropriate for comparisons, though has its own extensive limitations.[v] While the impact of divestment could be less (as indicated by Ritchie and Dowlatabadi's analysis) or greater (via a different selection of companies), the mean provides a more reasonable estimate of the expected impact of divestment. The mean of an industry is also appropriate as comparisons between companies within an industry are problematic, as discussed later.

Several alternate investment scenarios are shown in figure 1, all of which indicate large reductions in carbon shadow[vi] Replacing the single largest outlier among the alternative energy companies, China Sunergy, with the average of the remaining 5, results in a carbon shadow reduction of 69%. Other scenarios considering full industry averages find carbon shadow reductions of 90% or larger. In keeping with Ritchie and Dowlatabadi's analysis I have considered divestment to various alternative energy manufacturing companies from the base fossil fuel investments. Divestment to alternative energy *generation* companies would likely result in a much larger reduction in carbon shadow. Divestment could also increase the carbon shadow depending on the choice of companies divested from and reinvested in.

In contrast the PICS report considers a single alternative set of companies and finds only a 22% reduction. This difference illustrates the sensitivity of the results to the model assumptions and data used.[vii]

From the 22% reduction and the endowments total carbon shadow Richie and Dowlatabadi find that "*substituting renewable energy companies in this scenario has reduced the overall endowment's carbon shadow by three-tenths of a percent. This leads us to estimate that using similar strategies to divest UBC's endowment from all oil and gas company equities would likely reduce its exposure to greenhouse gas emissions by around 3%."*

This is a small impact. However these numbers should be interpreted with caution. Using the average solar and wind industry performance finds a 12.7% reduction in place of 3%. This compares favorably to the maximum 13.9% reduction possible in this divestment scenario. Reducing the remaining 86.1% of the endowment's carbon shadow not due to investments in fossil fuel equities would require either the shifting of additional investments to minimize the carbon shadow (similar to the white paper *Divestment Scenario Two)* or future reductions in the greenhouse gas intensity of the economy, which are only captured retrospectively by the SIC analysis (discussed in point 4.)

It should also be noted that *Divestment Scenario Two* does not analyze divestment from fossil fuel companies. The scenario instead studies a rearrangement of investments between exchange-traded funds with relatively similar portfolios and carbon shadows. It is thus not surprising that this exercise finds minimal changes in the carbon shadow.

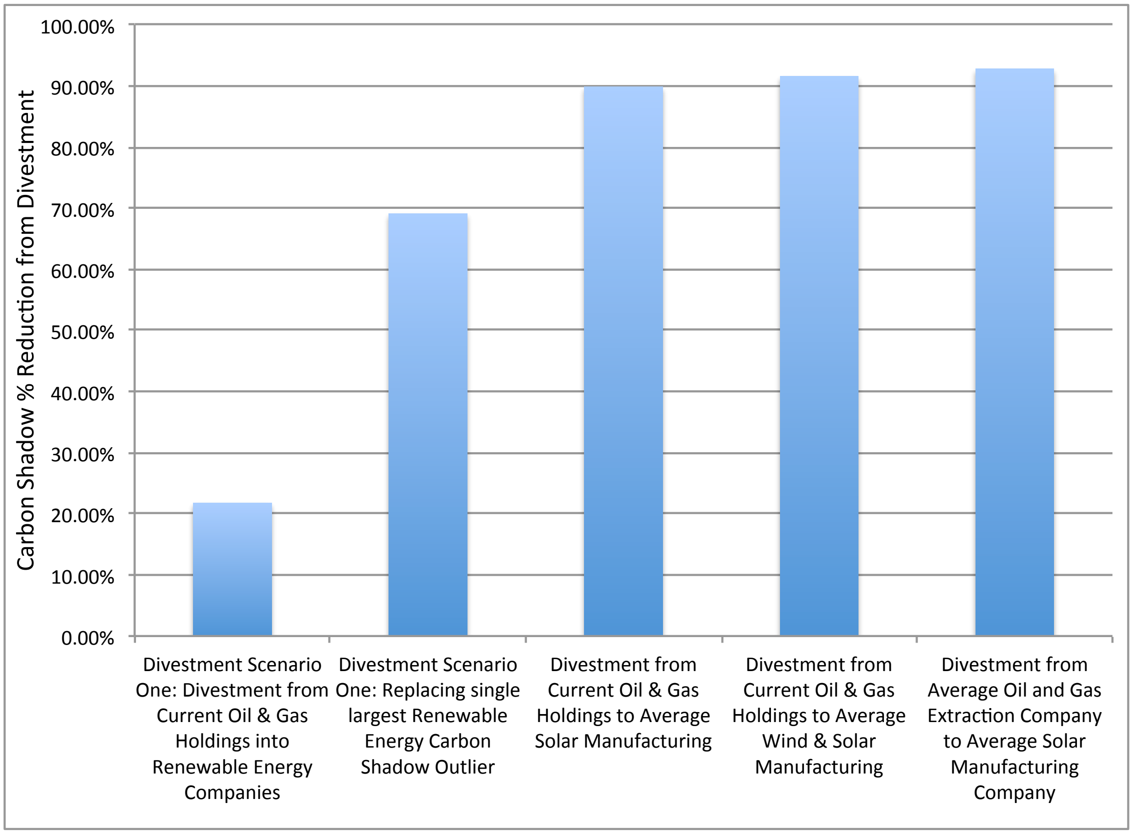

Figure 1 – Comparison of the PICS white paper *Divestment Scenario One* to similar alternative divestment scenarios. Column one shows the white paper *Divestment Scenario One.* Columns two through four consider divestment from the same oil and gas companies as *Scenario One* to various alternative investments. Column five indicates that only the alternative energy companies were not representative of their industry. Column height indicates the percent reduction in carbon shadow for this set of investments.

2) The "carbon shadow" is substantially different from a "carbon footprint."

The carbon shadow is a production-based measure that accounts for all carbon emissions accruing up to the point of an industry's sales. In the case of coal-fired electricity, this would account for nearly the full life cycle, from coal mining, to transport, to equipment repairs and car washes, to combustion, the last of which accounts for the vast majority of emissions. However, in the case of a company that extracts and sells bitumen from Canada's oil sands, the firm's carbon shadow would include only emissions associated with the process of extraction. It would not include the emissions from upgrading, refining, transporting, and burning the oil sold, which comprise 70-80% of the well-to-wheels emissions associated with a barrel of oil sands-derived oil.[viii] Even an integrated gasoline retailer's carbon shadow would exclude the majority of emissions as they occur after the point of sale from combustion for driving. Similarly, the carbon shadow of the natural gas industry would include emissions associated with production and pipeline transport, but not combustion by the final user.

While these differences are of course completely understood by Ritchie and Dowlatabadi, and this attribution of emissions is standard in the literature, readers contemplating investment decisions based on the SIC must take care not to conflate the life-cycle carbon footprint of an energy source like oil or a product for sale like a car with the carbon shadow of investments in related industries.

3) The carbon shadow is highly sensitive to financial performance and should not be used to inform investment decisions within an industry.

The SIC uses two values to calculate the carbon shadow: the GHG intensity of an industry, and the price-sales ratio of an industry or company. Greenhouse gas intensities from the underlying EIO-LCA model are available for industrial sectors only, not individual companies. Differences in carbon shadow between companies within an industry are then due to financial factors only and do not reflect any differences in greenhouse gas emissions due to technology or energy inputs. For example, differences in SIC carbon shadow between hydroelectric and coal power companies would be due only to their market capitalization and revenue, not their different energy sources.

Since the price-sale ratio can vary substantially from year to year and company to company, the carbon shadow can fluctuate substantially without any change in greenhouse gas emissions. For example Broadwind, one of the wind power companies considered in the *Divestment Scenario One*, had an annual P-S ratio of 3.55 in 2009. The company then apparently ran into financial troubles and had an annual P-S ratio of 0.04 in 2012, due to its drastically lower market capitalization. This occurred despite Broadwind's revenue remaining nearly unchanged over this period.

This financial change over three years increases the carbon shadow of investing in Broadwind by 8,775%, and occurs without any significant change in greenhouse gas emissions from Broadwind. In this situation, divesting from a wind turbine company to an oil company would reduce the carbon shadow of the investment.

As the price-sale ratio is only one of many indicators used in making an investment decision, and it varies substantially, the carbon shadow should not be used to inform investment decisions within an industry.

4) The Shadow Impact Calculator is based on past greenhouse gas intensities and doesn't address how to affect future emissions.

The shadow impact calculator concept tells us how *past* carbon emissions are associated with an investment today, not how emissions will change in the *future* if an investment affects what type of energy is produced or what goods are consumed. By design, the input-output model underlying the SIC approach cannot incorporate the prospective benefits of a structural change in energy supply investment. This limits the usefulness of the SIC in discussing key questions around switching to a low-carbon economy, including divestment.

Consider the following example. A society is choosing between continuing to power its economy with fossil fuels or switching to a hypothetical fusion technology. A fusion power plant requires a very significant up front investment of energy to construct, which must initially come from the existing fossil fuel energy supply. Subsequent fusion power plants could be built using the existing fusion power, thus allowing an indefinite low-carbon economy.

Strikingly, a SIC analysis would attribute similar carbon shadows to investing in these two very different options: increasing GHG emissions from fossil fuel energy, versus an eventual complete switch to low-carbon energy. In other words, if we were to base present-day investment (or divestment) decisions on the SIC, we could paradoxically conclude that switching to an alternative energy-only world has a carbon shadow similar to that of an extensively GHG-emitting world. This demonstrates the practical difficulty with a carbon shadow concept rooted in a retrospective analysis of greenhouse intensities instead of a full lifecycle analysis.

Ritchie and Dowlatabadi acknowledge this limitation, noting "*it is not immediately clear how to marry aspirations that seek structural change through decisions to divest from fossil fuel companies with the outputs of EIO-LCA models. Were a fossil fuel divestment campaign successful in reshaping the architectures of economies, the resulting transitions would only be captured in retrospect by these input–output models*."

The goal of investors making decisions mindful of climate change should be exactly that: to contribute to reshaping the economy's structure from one powered by fossil fuels to one powered by alternative energy.

In light of these limitations it remains unclear what value an analysis brings to the debate about divestment, if it cannot give recommendations on where to invest to reduce greenhouse gas emissions.

Endnotes

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[ii] Ritchie, J., & Dowlatabadi, H. (2014). *Understanding the shadow impacts of investment and divestment decisions: Adapting economic input-output models to calculate biophysical factors of financial returns*. Ecological Economics, 106, 132–140.

[iii] Ritchie, J. & Dowlatabadi, H. (2015). *Fossil Fuel Divestment: Reviewing Arguments, Implications, & Policy Opportunities*. Pacific Institute for Climate Solutions.

[iv] The Ecological Economics paper considers 7 firms including a uranium mining company and the PICS paper considers the same set excluding uranium mining. I do not know if fossil fuel divestment advocates propose to also divest from nuclear industries. However as Ritchie and Dowlatabadi's papers frame the discussion in terms of fossil fuel divestment I use the 6 firms in the PICS scenario for the comparison.

[v] A full comparison would consider aspects such as the distribution of carbon shadows and how investment decisions are already related to the carbon shadow due to risk-adjusted returns and other financial factors. The straight mean of alternative investments may turn out to be quite different from plausible alternative investment portfolios.

[vi] I repeat the authors' SIC method using data contained in their paper's references; P-S ratios from the *Aswath Damodaran, 2013a* in reference (2) and sector level greenhouse gas intensities from the 2002 EIO-LCA model for Canadian and US industries as needed. Alternative energy P-S ratios are not available prior to 2014, and it is also unclear what sector P-S should be used. The six alternative energy companies considered come from at least three separate industrial sectors and I could not find a crosswalk between the P-S sectors and the NAICS sectors used for GHG intensities. As a result, the most plausible P-S ratios for solar and wind appear to be the "Green & Renewable Energy" sector from 2014. For comparison, using P-S ratios from the semiconductor manufacturing industry for solar panel manufacturing results in 79% reduction in carbon shadow instead of 90%.

The authors have stated (personal communication) that they proxy the GHG intensity of solar firms with silicon manufacturing, hence their focus on solar manufacturing, not solar power generation. This proxy may be the right order of magnitude for solar panel manufacturing, but not solar power generation. The authors' analysis aggregates both types of companies and it is unclear what impact this has.

For each dollar of sales from a solar panel manufacturer a solar panel must be constructed and a quantity of energy used, here supplied by fossil fuels. A solar power facility is constructed once, releases the majority of GHGs during construction, and then produces energy for the plant lifetime of perhaps 30 years with minimal further releases of GHGs. Using the emission intensity of semiconductor manufacturing for solar power generation is equivalent to the GHG intensity involved with building a solar power plant, releasing GHGs associated with the construction, producing energy for a year, and then tearing down and rebuilding the solar power plant the following year.

Accounting for this ~30X overestimate gives a highly speculative 99.8% reduction in shadow carbon due to divesting from the PICS fossil fuel base case to the average solar power generation company. This example highlights why environmental lifecycle analysis considers the total emissions over the lifecycle of a facility or product, in contrast to the single-year snapshot approach underlying the SIC.

[vii] I have followed Ritchie and Dowlatabadi's approach in comparing oil extraction to alternative energy companies. The change in carbon shadow from divestment to unspecified alternate investments would depend heavily on the exact alternate investments chosen.

[viii] Canadian Oil Sands: Life-Cycle Assessments of Greenhouse Gas Emissions. Congressional Research Service (2014) https://www.fas.org/sgp/crs/misc/R42537.pdf