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LIFE CYCLE IMPACTS OF DIVESTMENT: APPLYING AN ECONOMIC INPUT-OUTPUT LCA MODEL TO MEASURE FINANCED EMISSIONS

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ABSTRACT

In recognition of the long-term impacts resulting from financial decisions, a growing number of campaigns are advocating divestment from companies responsible for high levels of carbon emissions. However, a systematic understanding of divestment is needed for an examination of the social, economic and environmental impacts that extend beyond the currently stated political motivations to divest.

We have developed the Shadow Impact Calculator (SIC) based on economic input-output life cycle assessments (EIO-LCA) as a tool to examine broader impacts of investment decisions. A portfolio's "shadow footprint" represents the economic, social and environmental impacts underlying an investor's decision to hold equities in particular companies, economic sectors or nations. We show which sectors of the economy have particularly large or small carbon shadows. To demonstrate the use of SIC we examine the endowment investments of a Canadian university. We also show how the immediate economy-wide impacts of divestment are often much smaller than would otherwise be expected.

KEYWORDS

Financed emissions, environmentally extended input-output, economic input-output life cycle assessment, divestment, financial holdings, biophysical impacts, climate change, two-degree investing, lifecycle assessment, externalities

1. INTRODUCTION

Financial investments are inherently a multi-attribute decision. Traditionally, the investor seeks to balance risks and rewards in their portfolio. Here we introduce a new methodology for assessing the broader impacts of such decisions.

Recent campaigns advocating for divestment have focused on pressuring institutional investors to remove funds from carbon intensive financial holdings. This study seeks to understand the full life-cycle impacts of investment decisions through applying the Shadow Impact Calculator (SIC). SIC builds on the economic input-output life cycle assessment (EIO-LCA) (1) framework. We adopted this approach because no company operates in isolation from the whole economy and hence its footprint needs to reflect all interactions that allow it to function. Though this work has focused on carbon emissions, developing SIC as an extension to the EIO-LCA methodology opens the possibility of exploring many additional impacts of investment decisions.

When compared to alternative approaches, SIC provides the advantage of being applicable on a range of economic scales through using readily available public information. Once the composition of a portfolio's holdings are known in each sector, EIO-LCA can be applied to understand economy-wide effects. In the context of movements advocating divestment for climate change, this approach is useful for examining the life cycle impacts of decisions to move money from one sector to another. If the specific holdings of companies are known, the SIC model may be adapted to reflect the same precision. Furthermore, SIC is only one tool in a growing toolbox of assessments where none is yet capable of delivering a comprehensive picture of biophysical impacts of an investment (2).

A brief review of leading tools used to estimate emissions associated with an investment are summarized in Table 1. These approaches range across a wide scale. At the micro-scale, assessments use data reported from companies to calculated financed emissions. The micro-scale approach can be combined with meso and macro methods to obtain a more comprehensive calculation. An example of a multi-scale approach to calculating financed emissions is exhibited by Trucost[1] which uses a comprehensive database of company profiles combined with input-output models (EE-IO) and LCA data on products (2).

It is difficult to determine how closely the proprietary approaches listed in Table 1 resemble the EIO-LCA methodology presented in this work. The process by which EIO-LCA calculates the biophysical impacts associated with economic activities relies on EE-IO data. Where it appears Trucost, Inrate

[1] Trucost is considered the industry leader in calculating financed emissions. Their commercial activities generate roughly £2 million each year of which about 50% is devoted to investor related activates.

and EIO-LCA may differ is that in applying these EE-IO matrices, EIO-LCA traces the impacts of economic activity throughout the entire supply chain.

Table 1. Available methodologies for calculating financed emissions (contents adapted from 2˚C Investing Initiative Comprehensive Review) (2)

Model Name	Methodology	Scope	First Availability
Trucost	Extensive database of carbon data reported by companies + proprietary EE-IO model for non-reporting companies	More than 4,500 listed companies	2006
INRATE	EE-IO statistical model supplemented with LCA data of products	More than 2,800 listed companies	2006
Profundo	Tracking fossil-fuel company transactions using Bloomberg and public data	Bank ratings based on financing provided to fossil-fuel extraction	2011
Cross-Asset Footprint	Based on Inrate data extrapolated to include financial instruments beyond equities	Listed non-financial companies and financial institutions, sovereign bond, loans, mortgages and green projects	2012
South Pole Carbon Screener	Extrapolation for each sector based on reported carbon data	Every listed company	2012
Camrdata Carbon Screener® Model	Carbon Disclosure Project Data	Roughly 8,000 listed companies	2013
ASN Bank	Based on Trucost for equities along with reported data and national statistics for other products	Methodology applied to its own balance sheet to reach carbon neutral by 2030 goal	2013

Understanding the scope and size of financed emissions are part of the rationale for active investing towards mitigating or reversing drivers of environmental change. The 2012 Landscape of Climate Finance Report by the Climate Policy Initiative found that global climate finance reached approximately USD 350 billions in FY 2011. Funds for current climate finance initiatives came primarily from the private sector in OECD nations. Public and private intermediaries have played an important role in channeling investments (3). The IEA forecasts that additional investments of USD 1 trillion per year are needed in energy technologies to achieve their scenario (2DS) for an 80% chance of limiting long-term global temperature increase to 2˚C (4).

To demonstrate how SIC can be applied to help in understanding the life cycle impacts of divestment, the endowment investments of a leading Canadian university are analyzed for their shadow footprint using statements issued from the campus' Treasury department.

2. METHODOLOGY

The EIO-LCA framework is developed from input output tables of a national economy. These tables reflect the cost of goods sold and bought. The economic prospects of a company (i.e., exposure, growth and profit sharing) determine its valuation. Thus, different sectors and companies enjoy very different Price to Earnings ratios. In order to calculate the shadow footprint of an investment, we determine its revenues and its share price at a given date. We then use the Price-Sales (P-S) ratio as the scaling factor between its price and the measured economy-wide impacts of holding equity in that firm or sector as depicted in Figure 1. This process allows the SIC to determine how much of a particular company's ecological impacts are held by a specific investor.

Figure 1. Methodology for applying an EIO-LCA model to a portfolio of financial holdings

2.1. Case Study: SIC Applied to Holding 1000 dollars in Canadian National Railway

For illustration, we follow the steps of applying the SIC to estimate the shadow footprint of holdings in the Canadian National Railway (CNR), one of the investments of our selected campus endowment. CNR reported $ 9.9 billion in revenues for the twelve months ending December 2012. Its market cap at the time was $ 36.6 billion, yielding a P-S ratio of 3.69. Thus, the $1000 in equity represented $271 of sales by CNR. The EIO-LCA Canada Industry Account model provides the economy-wide impacts of CNR delivering these services: 250 kg CO_2 equivalent gases were emitted and 3.15 GJ of energy consumed.

2.2. Case Study: SIC Applied to a University Endowment's Holdings to Understand Divestment Impacts

To calculate the 'shadow footprint' of the selected university endowment, the following steps were performed:

1) Campus endowment investments from holdings reported on October 23rd, 2012 were identified by nation, type, and sector in order to understand which EIO-LCA model was most applicable.

2) Where specific equity holdings were listed, market data on share prices as of the endowment statement issue date were gathered along with data on market capitalization values and annual revenues.

3) Reported revenues for each investment holding were used to determine the emissions and energy inputs associated with business activities in associated sectors for FY 2012-2013 operations with the most recent EIO-LCA models[2].

4) To determine the campus's share of each company's biophysical impacts, the share price to sales (P-S) ratio was calculated or assigned for each holding by establishing a relationship between revenues and prices. Where data were available, a P-S ratio was calculated as a relationship between the market capitalization to the annual revenues of each company. For ETFs and other aggregated funds where knowledge of specific holdings were rarely available, the allocation of each ETF by sector was gathered from available fund information and a sector average P-S ratio was used[3].

5) Results for each holding were aggregated to determine an overall annual shadow footprint associated with the university's investment holdings: the amount of emissions and energy supporting the annual investments of the endowment.

2.3. Different Sectors Cast Different Shadows

Combining sector average P-S ratios for 82 sectors with the SIC model of the US economy provides a perspective on the range in GHG impacts supporting investments in various sectors. Figure 2 displays the sectors of the US economy with the highest GHG emissions associated with investment dollars.

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[2] The EIO-LCA 2002 United States Benchmark Producer Price model was applied to US and international holdings (5). The 2002 Canada Industry Account Model was applied to Canadian holdings (6). Both models can be accessed online at http://www.eiolca.net and are publicly available for use.

[3] For a list of current P-S ratio for US equity sectors see the NYU Stern Database of Revenue Multiples by Sector (7).

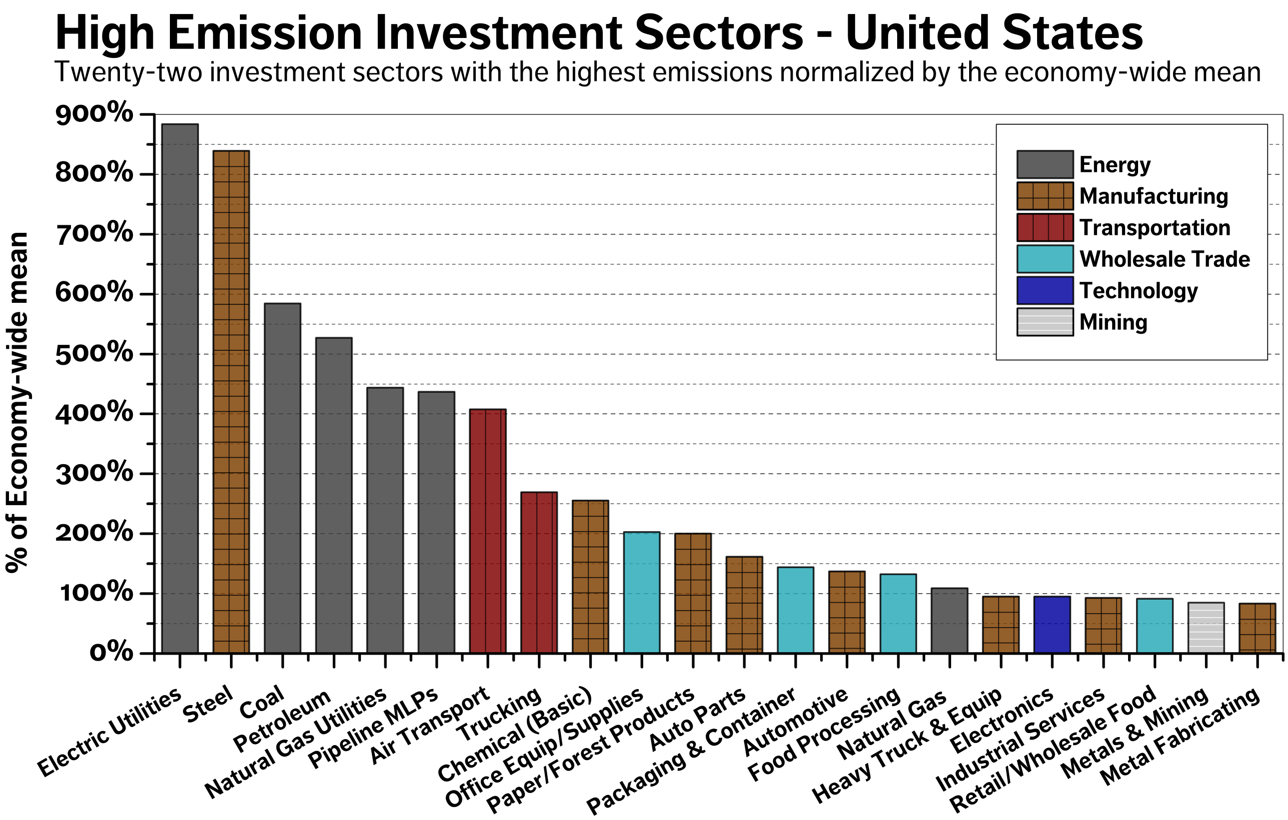


Figure 2. Normalized carbon emission shadow footprint for the US Economy's twenty-two highest emission sectors (normalized to national mean).

Investments in sectors with the highest carbon footprint match intuition: electric utilities, steel, coal, petroleum and natural gas utilities round out the top five. For the top twenty-two sectors investments of USD 1 million would be supported by GHG emissions 8.8 to 0.9 times the economy-wide mean of 854 tons of CO_2.

Investments in sectors with the lowest footprints are supporting highly financialized or technologically advanced areas of the economy. Financial and information services round out the investments with the least associated GHG investments showing impacts of 2.5 % to 10.5% of the economy-wide mean. Because banks and many other investment companies report income rather than revenues, they are assigned a dashed outline in Figure 3. This study understands the role of financial services as enabling the activities of other economic sector, thus boundaries are porous. Yet, even the activities of securities brokerages, equity management, insurance, financial services, banks and investment companies have associated life cycle emissions: investment managers still use energy in their commute to the office or use electricity to power trading stations. The emissions associated with these activities are captured in the EIO-LCA models for financial and insurance sectors accordingly.

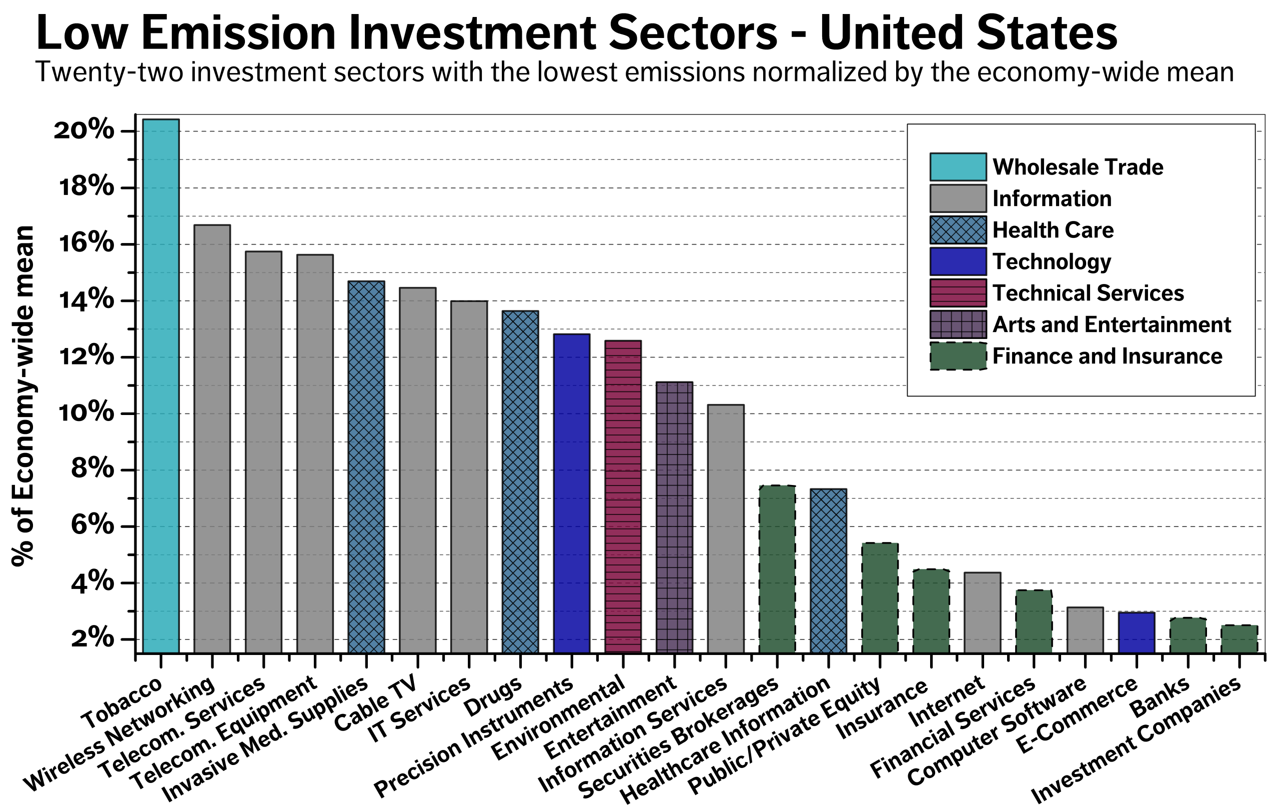


Figure 3. Normalized carbon emission shadow footprint for the US Economy's twenty-two lowest emission sectors (normalized to national mean). Note: Financial and insurance industries are marked with a dashed boundary because of their role in enabling cross-economy activities despite relatively low shadow emissions associated with their life cycle operations.

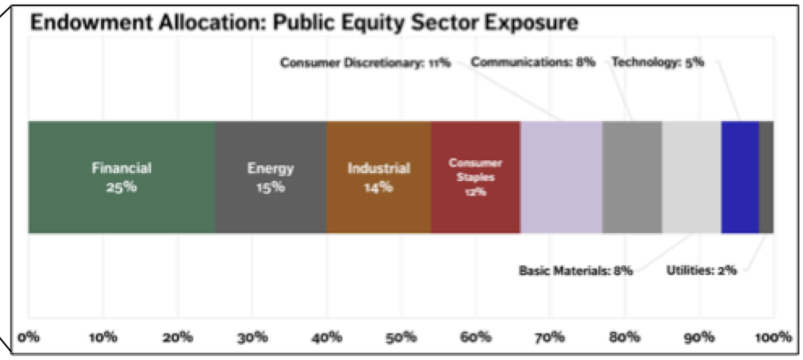
In the absence of further concerns, an investor could use the distribution of GHG impacts demonstrated in Figures 2 and 3 to optimize his or her portfolio. However, investment decisions will also consider their risk tolerance and return characteristics. We discuss the concurrence of evaluation volatility and shadow impacts elsewhere (8).

3. CASE STUDY: A UNIVERSITY ENDOWMENT'S SHADOW FOOTPRINT

The endowment of a major Canadian university with publicly available investment listings was chosen to demonstrate SIC on an actual portfolio. The market value of the campus' endowment investments was $ 952 million on October 23rd, 2012. The selected endowment was allocated to the following investment classes and public equity sectors as detailed in Table 2.

Table 2. Allocation Of The Selected Campus' Reported Asset Class Profile For All Endowment Investments (Left) And The Endowment's Corresponding Reported Public Equity Sector Exposure (Right)

Endowment Allocation: Asset Class	
Fixed Income	18.8%
Private Equity	11.5%
Public Equities	58.4%
Canada	22.8%
United States	9.7%
Global + Emerging	25.9%
Real Estate	6.3%
Infrastructure Equity	4.0%
Hedge Funds of Funds	1.0%



More than a quarter of the endowment is invested in global public equities, including emerging markets and the Eurozone. Roughly 23% of the endowment was in Canadian public equities. Just under 19% is in fixed income investments of which 1.1% was cash and 17.7% in bonds. The rest of the endowment was split among private equity, public equities in the United States, real estate, infrastructure equity and hedge funds.

Of the 58.4% of the endowment invested in public equities, the right half of Figure 4 shows the allocation by sector. Of this $ 556 million, the top two sectors receiving investments were financials and energy. Industrial and consumer staples constituted the next quarter of investments. The rest was split among consumer staples, consumer discretionary, communications, basic materials, technology and various utilities.

A SIC analysis applied to campus endowment investments measured a total carbon shadow footprint of 550,000 tCO_2e. To put this number in context, the campus' annual Climate Action Plan was referenced for the university's GHG inventory. In 2012 the campus' scope 1 and 2 emissions were 60,715 tCO_2e. Reported scope 3 emissions included commuting, staff and faculty air travel, building life cycle and solid waste, totaling 63,990 tCO_2e in 2012. The endowment's annual carbon shadow footprint was more than nine times the university's scope 1 and 2 emissions and more than four times that of the scope 1,2 and 3 emissions combined – yet the endowment returns only fund 3-4% of its annual budget.

The carbon intensity of selected campus' investments carbon was measured as a ratio of tCO_{2e} per million dollars invested ($tCO_{2e}/mn\$_{inv}$) and compared to economy-wide numbers for Canada and the United States in Table 3.

Table 3. Benchmark Comparison for Carbon Intensity

	GDP (Billions/yr)	GHG Emissions (Mtonnes/yr)	Carbon Intensity ($tCO_{2e}/mn\$_{inv}$)[3]
Canada	1,805 [4]	702 [5]	390
United States	16,420 [6]	6700 [7]	410
Selected Campus Endowment	0.95	0.56	560

This particular endowment exhibits a notably higher carbon intensity than the Canadian and US economies. We explore the question of whether this is a natural outcome of the risk reward characteristics sought by academic institutions elsewhere (12).

4. APPLYING DIVESTMENT CRITERIA

We next use SIC to explore two climate change divestment scenarios: (1) the endowment's direct holdings of oil, gas and mining totaling $ 8.7 million are placed in alternative energy companies[8]. selected at random; (2) exchange-traded funds (ETFs) which hold the majority of the endowment's equity investments are re-allocated to reduce the endowment's carbon shadow footprint.

4.1 Divestment Scenario One: Towards Alternative Energy

Seven alternative energy companies were randomly selected to receive the endowment's $ 8.7 million directly invested in seven oil, gas and mining companies. The new portfolio is comprised of four solar PV companies, a waste-to-energy company, a battery manufacturer and a wind turbine company.

[3] Values for calculated carbon intensities are reported with no more than two significant figures to avoid conveying a notion of false precision.
[4] Canada's 2011 Gross Domestic Product (GDP)
[5] Canada's 2012 GHGs (9)
[6] United States Q4 2012 GDP (10)
[7] United States 2011 GHGs (11)
[8] Companies listed as 'Power' in the NYU Stern Price-Sales Database were numbered 1-101 and chosen with a random number generator, entities in the basket that had since been de-listed were replaced with similar companies.

Investment shifts are carried out to reflect a simple transfer of equities from an existing company to a new "green alternative". The original and new investments along with their amounts are represented in Table 4.

Table 4. Divestment Scenario One: Oil, Gas and Mining into Alternative Energy Companies

	Current Holdings			Scenario One Holdings		
		P-S Ratio	tCO_{2e}/mn$inv		P-S Ratio	tCO_{2e}/mn$inv
$ 1.76	**Cenovus**	1.52	1,600	**EnerSys**	1.09	350
$ 1.51	**Cameco**	3.16	170	**Sunpower**	1.56	390
$ 1.36	**Ensign Energy**	1.06	2,300	**Broadwind**	1.78	360
$ 1.16	**Encana**	3.22	770	**Canadian Solar**	.49	1,200
$ 1.03	**Talisman Energy**	1.71	1,400	**China Sunergy**	.15	4,000
$ 1.02	**Baytex**	5.52	450	**Solarcity**	17.33	40
$ 0.85	**Canadian Natural Resources**	2.21	1,100	**China Recycling Energy**	77.95	10
$8.7	**Original annual carbon shadow footprint**		**10,000 tCO_{2e}**	**Scenario one annual carbon shadow footprint**		**7,400 tCO_{2e}**

Outline of a divestment scenario where the endowment's investment funds in oil, gas and mining are moved into listed alternative energy companies for batteries, wind, solar and waste-to-energy

Note: All values in millions of US dollars, Price-to-sales (P-S) ratios accurate as of the endowment's disclosure of October 23rd, 2012

The original shadow footprint of the seven holdings was 10,000 tCO_{2e} per year. The new carbon shadow footprint in this divestment scenario is 7,400 tCO_{2e} per year, representing a 26% reduction. The entire endowment's shadow footprint was reduced by .49% with the divestment scenario outlined in this section. The $ 8.7 million divested represents .91% of the total endowment's market value[9].

In the next scenario the implications of moving a larger amount of the endowment are explored through re-allocating funds placed in high impact ETFs.

[9] SIC permits us to explore a great many divestment scenarios. The divestment scenarios covered here are not intended to serve as recommendations for action or as a comprehensive set of choices available to the institution's endowment in the case study, merely to demonstrate the potential of the SIC model.

4.2. Divestment Scenario Two: Reducing the ETF Carbon Shadow Footprint

A decision to divest the endowment's direct holdings in oil, gas and mining would leave the majority of the roughly $ 83.4 million invested in energy equities intact. Because most of the endowment's energy holdings are in ETFs, moving money between various funds has the largest potential impact on the investment shadow footprint for this portfolio. Table 5 summarizes the five largest ETFs in the selected portfolio carbon intensity of each fund ranked by $tCO_{2e}/mn\$_{inv}$.

Table 5. Target Endowment's Five Largest ETFs and their Carbon Intensity

	ETF Name	Carbon Intensity ($tCO_{2e}/mn\$_{inv}$)	ETF Structure
I	Leith Wheeler Canadian Equity Fund	430	Financials 33.3%, Energy 19%, Industrials 17.2%
II	Blackrock Active Canadian Equity Fund	460	Financials 33.1%, Energy 27.3%, Materials 15.8%
III	Leith Wheeler International Pool-A	630	Other 19.7%, Industrials 19.6%, Consumer Discretionary 14.3%
IV	SSGA S&P 500 Index Fund	760	IT 18.0%, Financials 16.0%, Health Care 12.6%
V	State Street S&P 400 Midcap	840	Financials 23.6%, Industrials 17.1%, IT 14.8%

For optimizing the endowment's carbon shadow footprint, two scenarios are considered for ETFs: (2a) moving funds from the highest carbon intensive funds (IV, V) to the top two funds with the lowest carbon intensity (I,II); in scenario (2b) we consider moving the entire $ 351.1 million in ETFs into the least carbon intensive fund to explore the impact of an extreme shift. These divestment scenarios are not intended to reflect the decision making process of actual investment managers as factors of return and risk aren't included.

The impact of these two divestment scenarios are summarized in Table 6. Moving $ 104.7 million from the State Street S&P 400 Midcap and the SSGA S&P 500 Index Fund into the Leith Wheeler Canadian Equity Fund and the Blackrock Active Canadian Equity Fund reduces the endowment's carbon shadow footprint by 4.2%. Placing $ 250.2 million from funds I-V into the least carbon intensive fund yields a carbon shadow footprint reduction of 11%.

Public institutions have to balance many different criteria when investing their endowments. Notably, ubiquitous budgetary shortfalls steer endowment managers towards holdings that generate income while limiting the risks to the principle invested. This and other salient factor have not been reflected in the scenarios used for illustrating the SIC framework. However, SIC can be extended to include these factors in its scope. Informing how an institutions investment portfolio can also reflect its ethos.

Table 6. Divestment Scenario Two: Results of ETF Carbon Optimization Scenarios

		New Fund Compositions as % of Endowment	
Fund	**Original Share**	**Scenario #2a**	**Scenario #2b**
I	11%	14% (I+V)	36.9% (I+II+III+IV+V)
II	7%	15% (II+IV)	0
III	7.9%	7.9%	0
IV	8%	0	0
V	3%	0	0
Net Impact on Carbon Shadow Footprint		**-4.2%**	**-11%**

5. CONCLUSION

Focusing on the direct equity holdings and ETFs that are heavily dependent on carbon emissions represent just two limited illustrations of this approach. SIC allows for a multi-criteria analysis that can include: how investments stimulate the whole economy, lead to employment, deplete resources, or release of various toxics into the environment. In our view, investment decisions can be improved if we combine the traditional risk - return measures with the socio-ecological aspects of the activities they finance.

But we should also note that any EIO-LCA base framework has a number of well-known limitations. These include: a coarse industry level resolution averaging impacts associated with a high valued (small footprint) product and a low value commodity (with a large footprint) if classified in the same category; it relies on historic economic activity and price information (the models rely on detailed statistics that are published 5 or more years after the survey date). Finally, EIO-LCAs are retrospectives of the economy's capital structure. It is not clear how to marry to aspirations of the divestment movement with the drivers of structural change.

In addition, SIC introduces new challenges when considering how markets price equities. Consumer sentiment and investor confidence go hand in hand with economic cycles; changing the distribution of impacts held by any one investor in this model. Irrational exuberance in one sector could dilute the apparent dependence SIC measures for any investment's biophysical components. A confident economy or a shortage in a particular sector would raise equity pricing and lower shadow impacts.

Despite these limitations, SIC holds the potential for detailing the complex relationships between financial and physical resources that are often obscured by solely relying on prices. While this study has focused on SIC's ability to understand the carbon intensity of financial holdings, our lens could look the other direction. SIC could be applied to understand how energy, water or other factors may impact financial systems. This methodology could provide insights on the relationship between energy metabolism and factors of financial performance.

Investment strategies claiming to be ecologically responsible yet reliant on a dematerialized economy are enticing yet impractical myths. We all still need shelter, food and other services only made possible through physical objects. If Canadians don't manufacture computer chips or steel in Canada, it does not mean that we no longer need or use these in our lives. While electric utilities have the highest shadow footprint, we cannot do without electricity, but we can do without coal-based electricity. This indicates a need for much finer tools to shape industry activities than simple divestment. Though this study has focused on annual carbon shadow footprints, relatively minor reductions accumulate over time. Lock-in effects of investments could also be modeled by SIC.

In this paper we have presented a systematic approach for evaluating various investment opportunities for their dependence on continued carbon emissions. We have shown how this approach can be used to assess climate change divestment scenarios. Our study shows that if the full lifecycle of economic activity is taken into account, it is difficult to reduce the total shadow footprint of an isolated investment portfolio until the whole economy (including necessary imports) has a lower carbon intensity.

REFERENCES

1. Matthews HS, Small MJ. Extending the boundaries of life-cycle assessment through environmental economic input-output models. J Ind Ecol. 2000;4(3):7–10.

2. Jean-Pierre Sicard. From Financed Emissions to Long-Term Investing Metrics [Internet]. Paris, France: 2˚ Investing Initiative; 2013 Jul. Available from: http://2degrees-investing.org/

3. Barbara Buchner, Angela Falconer, Morgan Hervé-Mignucci, Chiara Trabacchi. Landscape of Climate Finance 2012. San Francisco, United States: Climate Policy Initiative; 2012 Dec.

4. Energy Technology Perspectives 2012 [Internet]. Paris: International Energy Agency; Available from: http://iea.org/etp

5. Carnegie Mellon University Green Design Institute. US 2002 Industry Benchmark Model [Internet]. Econ. Input-Output Life Cycle Assess. [cited 2013 Aug 21]. Available from: http://www.eiolca.net/copyright/index.html

6. Carnegie Mellon University Green Design Institute. 2002 Canada Industry Account EIO-LCA Model [Internet]. Econ. Input-Output Life Cycle Assess. [cited 2013 Aug 21]. Available from: http://www.eiolca.net/copyright/index.html

7. NYU Stern School of Business. Price to Sales Ratios - January 2013 [Internet]. [cited 2013 Aug 23]. Available from: http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/psdata.html

8. Ritchie J, Dowlatabadi H. Forthcoming: Shadow Impacts of Investments in the Context of Risk-Return Metrics. 2014;

9. Environment Canada. Environment Canada - Environmental Indicators - National Greenhouse Gas Emissions [Internet]. [cited 2013 Sep 6]. Available from: http://ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=FBF8455E-1

10. US Department of Commerce BEA. Bureau of Economic Analysis - Gross Domestic Product [Internet]. [cited 2013 Sep 6]. Available from: http://www.bea.gov/iTable/iTable.cfm?ReqID=9&step=1#reqid=9&step=3&isuri=1&903=5

11. United States EPA. Inventory of Greenhouse Gas Emissions and Sinks 1990-2011 [Internet]. Available from: http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html

12. Ritchie J, Dowlatabadi H. Forthcoming: Thinking about a green investment: how investment managers view their role. 2014;

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