INVESTING FOR CLIMATE ACTION:
THE ROLE OF CAPITAL MARKETS IN ENABLING A LOW-CARBON TRANSITION

by

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This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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STATEMENT OF CONTRIBUTIONS

Truzaar Dordi was the sole author for chapter 1, chapter 3, and chapter 6, which were written under the supervision of Dr. Olaf Weber. Chapters 1 and 6 were not written for publication.

This thesis consists in part of four manuscripts written for publication. Exceptions to sole authorship of material are as follows:

Chapter 1: Truzaar Dordi: Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. Nicholas Palaschuk: Conceptualization, Investigation, Project administration, Resources, Validation, Writing – original draft, Writing – review & editing.

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As lead author of these three chapters, I was responsible for contributing to conceptualizing study design, carrying out data collection and analysis, and drafting and submitting manuscripts. My coauthors provided guidance during each step of the research and provided feedback on draft manuscripts.

ABSTRACT

Economies around the world face a stark choice – to bolster fossil fuel production and face climate catastrophe or to keep fossil fuels in the ground and face trillions in potential asset stranding. Capital markets, as influential stakeholders, have a central role to play in sustainability transitions due to their inordinate influence on the governance of the fossil fuel extraction industry. Using network analysis, this dissertation links fossil fuel firms to equity owners by distinguishing ownership characteristics of top shareholders and establishing a ranked list of the most prevalent shareholders based on emissions potential and network centrality. The results not only assert that financial markets can influence the trajectory of sustainability transitions as enablers for socio-technical transitions but also exemplify that power is concentrated among just a handful of powerful and path-dependent financiers. The dissertation concludes that a concentrated number of investors have the potential to influence the strategic direction and governance of these firms and should consequently be held accountable for financing the economic activities that contribute to climate instability. It directly contributes to the fragmented body of academic research on climate finance, energy policy, and sustainability transitions.

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Finally, to future generations – climate change is among the greatest challenges we face; a challenge is exemplified by the multitude of crisis in its peripheries. The call for action alluded in this dissertation is ambitious but feasible with concerted action. I remain (perhaps naively) optimistic for the future – and I commit that through grounded research, with scholarly rigour and integrity, I will continue to play a small but meaningful part in this global transition.

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1. INTRODUCTION

It is unequivocal that human influence has warmed the atmosphere, ocean and land.

- IPCC AR6

1.1 Earth – Our Home

Human activity has always altered the natural environment, but never have the effects been so profound. From command of fire to the industrial revolution, the magnitude, variety, and longevity of human-induced changes have radically transformed the planet (S. L. Lewis & Maslin, 2015). While there is some debate to its origin (S. L. Lewis & Maslin, 2015), it is widely recognized that human impacts have pushed the earth system outside the Holocene and towards a new epoch, in which human actions have become the main driver of global environmental change (Rockström et al., 2009). Humans are not passive observers on the planet; our actions are rapidly transforming the systems we depend on (S. L. Lewis & Maslin, 2015).

The 'great acceleration' of the 20th century has been a time of unprecedented growth, characterized by a major expansion in human population, hydrocarbon-based energy consumption, and increased affluence (Steffen et al., 2015). Fossil fuel production as the dominant source of energy saw a 16-fold rise over the 20th century, resulting in labour-saving, comfort-providing, and energy-efficient technologies that revolutionized the quality of life for much of the developed world (Smil, 2000). This was not without enormous environmental consequences; fossil fuel combustion has led to rising carbon emissions, increased atmospheric warming, and rising global temperatures (Smil, 2000). Fossil fuel production has since become ubiquitous to both prosperity and instability, entrenched in the very fabric of our economy and culture (Princen, 2015).

To maintain a safe operating space for humanity (Rockström et al., 2009), emissions must be rapidly curtailed. Emissions reductions have been a central point of climate discourse for over 30 years, yet, emissions continue to rise. We argue here that this is partly due to the incremental nature of the emissions reduction paradigm; early research and policy response on anthropogenic global warming focused on "controlling emissions rather than the global thermostat" (Randalls, 2010, p. 600). This emissions reductions paradigm, dictated by estimating future scenarios based on potential climatic outcomes, failed to explicitly draw policy conclusions about the maximum level of warming to remain within a safe operating space and has thus resulted in decades of incremental action on carbon reductions(Morseletto et al., 2017; Randalls, 2010). Temperature targets gained acceptability in policy recommendations in the mid-1990s, during which point the 2°C target became a political anchor for mitigation policy (Morseletto et al., 2017; Randalls, 2010). However, it was not until the 2009 Copenhagen Accord that the temperature target was ratified into international climate discourse (Gao et al., 2017). Critical to effective climate policy, the 2°C target presents an absolute outcome for decarbonization by which scientists, economists, and policymakers can work back from when designing effective interventions (Randalls, 2010).

Fossil fuel production and combustion is the single leading cause of anthropogenic climate change (Hansen et al., 2008; Heede & Oreskes, 2016; Quéré et al., 2013). Increased production of long-lived greenhouse gases in the atmosphere, most affiliated with increased fossil fuel use, has raised global temperatures by nearly half of the globally accepted 2°C target agreed upon in the 2009 Copenhagen Accord (IPCC, 2022). The effects of climate change are already being experienced around the world - an additional 2°C over preindustrial levels would irreversibly transform humanity and the ecosystems they depend upon throughout an increasingly inhospitable Anthropocene era. Given the urgency to restrict carbon emissions and mitigate the worst effects

of global warming, climate scientists now call for a ceiling limit on emissions - a "carbon-constrained" future driven by a socially (as opposed to physically) imposed limit to carbon production (Jaccard et al., 2018).

1.2 Water – Fossil Fuels as Agents of Cultural Change

To understand fossil fuels as simply a natural resource or source of energy would be a disservice; fossil fuels are *agents of cultural change* (Princen, 2015). Like water to fish, fossil fuels are essential but unnoticed, pervading through all aspects of life. Fossil fuel interests consequently occupy our political, economic, and cultural institutions and obstruct progress on carbon emissions reduction.

Institutional inertia and lock-in may be among the greatest threats to climate action. Industrial economies appear to be locked into fossil-fuel-based systems in spite of their own environmental costs and the existence of competitive alternatives (Hudson, 2019; Unruh, 2000). This lock-in implies that systematic forces actively impede changes to incumbent systems. Legal structures (like counterproductive subsidy programs), social customs (such as dependence on automobiles) and institutional interests (such as risk-averse lending practices) build feedbacks that inhibit technology adoption and exacerbate lock-in conditions.

In the context of fossil fuels, power and influence reside among a tightly-knit and highly influential set of actors, who, being smaller in number, can coordinate substantial resources to resist change that threatens their interests. Likened to an entrenched oligarchy (Carroll, 2017), just 90 major industrial carbon producers are responsible for 57% of the observed rise in atmospheric CO2 since 1980 (Ekwurzel et al., 2017; Frumhoff et al., 2015a; Heede, 2014). In Canada, the majority of oil

sands production is owned by four companies, and consequently, there is a significant incentive among those owners to maintain the status quo (Hussey & Janzen, 2018). Equally, the same level of consolidation of power is seen among institutional investors - the top 10 of whom account for 43 percent of ownership across the top 50 fossil-fuel companies (Carroll & Huijzer, 2018). Fossil fuel production is thus controlled by a powerful and entrenched minority, an undemocratic elite that maintains power indefinitely through deep social ties that are structured to maintain status quo. Consequently, fossil fuel firms, as agents of cultural change, have immense influence not only on production but, more insidiously, on the fabric of the global economy.

If, however, the world is to limit warming to under 2°C, the majority of fossil fuels must remain in the ground. The global carbon budget estimates how much can be burned if humanity is to meet its accepted target (Quéré et al., 2013). Seminal research on carbon emission targets calculates that if global temperatures are to be limited to under 2°C (with 80 percent probability), carbon emissions must be limited to 565 gigatonnes of carbon dioxide between 2010 to 2050 (M. R. Allen et al., 2009; Meinshausen et al., 2009). To put this emission target in context, existing proven fossil fuel reserves at the time of the study (those which have a 90 percent certainty of being extracted) amount to 2,795 gigatonnes of carbon dioxide (Campanale & Leggett, 2011), over five times as much as what can be safely emitted. Any effort to limit global temperatures at the 2°C target will thus require nearly 80 percent of proven reserves remain grounded. Updated figures estimate that to mitigate warming under 1.5°C, no more than 230 gigatonnes of carbon reserves may be burned (Matthews et al., 2021). For context, the 200 largest fossil fuel firms alone have the potential to emit 647 gigatonnes, three times greater than the global carbon budget, if existing reserves are burned.

The concept of the carbon budget has been instrumental in shifting climate discourse from reductions in demand-side end-uses toward rapidly restricting the supply of fossil fuels (Lazarus & van Asselt, 2018). Though fossil fuel production is agreed to be the leading source of anthropogenic climate change, policy discourse remains dominated by demand-side (as opposed to supply-side) solutions like carbon pricing, energy retrofits, and electrification (Green & Denniss, 2018; Kemp & Van Lente, 2011; Piggot et al., 2018). However, effective climate solutions will require 'cutting with both arms of the scissors' (Green & Denniss, 2018), that is, also curtailing fossil fuel supply. While a reduction in energy demand is necessary, it will not be enough to mitigate climate change alone (Steffen et al., 2018). Supply-side policies are interventions that limit the exploration, extraction or transportation of fossil fuels (Lazarus & van Asselt, 2018). These policies can come in the form of economic instruments like production taxes or revoked subsidies, regulatory approaches like prohibitions or quotas, or through government provisions that restrict public financing or compensate, leaving reserves underground (Lazarus & van Asselt, 2018). These policies may be more effective as well; Erickson et al. (2018) estimate that simply stopping the issuance of new oil well permits could reduce 2030 oil production by about 70 percent. Supply-side policies would slow investment in fossil fuel production, limiting carbon lock-in and institutional inertia.

1.3 Air – Capital Markets as Contextual Systems

We assert in this dissertation that capital markets, though traditionally ambivalent, should take an active role in enabling a low-carbon transition - not only by shifting capital away from carbon-intensive industries and toward low-carbon alternatives but by wielding its influence to enable a

low-carbon transition from within the industry. There may be precedence for capital markets to act to enable a low-carbon transition.

First, capital markets have historically been foundational in supporting economic (Perez, 2002) and sociotechnical (Loorbach et al., 2017) transitions and will be vital once again in a low-carbon transition. Within the theoretical framing of the multi-level perspective, capital markets can be contextualized as systemic intermediaries (Kivimaa et al., 2019; van Lente et al., 2011), who, through their function of resource mobilization (Bergek et al., 2008; Hekkert et al., 2007; Polzin et al., 2016), have the capacity to disrupt existing socio-technical regimes and drive a low-carbon transition (Geddes & Schmidt, 2020; Naidoo, 2020; Nykvist & Maltais, 2022; Seyfang et al., 2010). Though capital markets often remain ambivalent in the allocation of financial resources (Wiek & Weber, 2014), significant resources remain tied within the fossil fuel industry. Financial actors can influence fossil fuel companies through a combination of debt and equity financing (Galaz et al., 2018). Specifically, equity owners as the focus of this study, can influence organizations through engagement or divestment (Appel et al., 2016; Dimson et al., 2015). Consequently, we posit that financial actors that maintain holdings in fossil fuel firms and don't wield their influence to enable a low-carbon transition, should be held accountable for their contribution to fossil fuel production and, ergo, to climate instability.

Second, though critical for climate stability, such a transition could result in disruptive adjustments in carbon-intensive sectors, with significant consequences for economic stability (Campiglio et al., 2018; Geels et al., 2017). Restricting fossil fuel production in line with global carbon budgets poses substantial climate-related transition risks. If existing reserves remain grounded, fossil fuel firms may suffer from unanticipated or premature write-downs in the form of stranded assets (Caldecott et al., 2014). The potential value of stranded assets varies substantially but is non-

negligible (Curtin et al., 2019; Semieniuk et al., 2022), ranging from $2 trillion to (Leaton, 2015) $28 trillion in losses (M. C. Lewis et al., 2014). Latest estimates by Carbon Tracker Initiative predict that over $1 trillion of oil and gas assets risk becoming stranded, and over $600 billion are held by publicly listed companies in financial centers like New York, Moscow, London, and Toronto (T. Allen & Coffin, 2022). It is possible that these estimates are still undervalued; Weber, Dordi, and Oyegunle (2020) pose that stranded assets may have systematic and confounding effects, with consequences for financiers, governments, and civil society. More, stranded assets could trigger cascading losses throughout interconnected financial systems, resulting in a global financial crisis (Cahen-Fourot et al., 2019; Campiglio et al., 2018). Inaction may fare even worse. Cleary and Willcott (2022) estimate that over $2.7 trillion in capital outputs may be lost in Canada alone in a 2°C warming scenario. There is thus increasing evidence indicating that continued investment in fossil fuel industries is not only contradictory to global carbon reduction targets but is also a failing investment strategy (Arbuthnott & Dolter, 2013; Dordi & Weber, 2019b; Henriques & Sadorsky, 2018; Hunt & Weber, 2018; Trinks et al., 2018). Capital markets thus have a vested interest in both economic stability and climate stability (Hawley & Williams, 2000).

Finally, there is a compelling case moral for shifting away from the fossil fuel industry (Dordi & Weber, 2019a). Lenferna (2018) summarizes several convincing arguments to explicate moral reasonings against fossil fuel investments. First, financiers that support the fossil fuel industry contribute to sustaining wrongful harm by directly or indirectly investing in industries whose actions run contrary to international climate targets and whose actions increase the likelihood of harm caused by climate change (Barry & Wiens, 2016; Moss, 2017). Furthermore, given the role of the fossil fuel industry in spreading misinformation to prevent climate action, investors implicitly endorse efforts to actively undermine climate progress. Second, financiers have the

moral obligation to promote broader collective action on climate change. There is a deep body of literature that examines how divestment, for example, can shift moral, political, cultural, and financial norms (Ansar et al., 2013; Ferns et al., 2022; Grady-Benson & Sarathy, 2015; Gransaull et al., 2022; J. Rowe et al., 2021; Yona & Lenferna, 2016). Thus, the moral case for financiers to intervene in the fossil fuel industry is two-fold—to stop being complicit in or directly contributing to the unjust harm caused by climate change and to promote action that prevents this harm.

The low-carbon transition thus relies on the economic activities of the fossil fuel industry and the associated actions of key financial actors. Given the financial and ethical obligation and the immense potential influence capital markets yield as critical context systems, financial actors must play a central role in sustainability transitions research and policy.

1.4 Fire – The Spirit of Resistance

The question remains; which *bubble* will pop? Will humanity choose a path of continued fossil fuel production and climate catastrophe or the path of emissions reduction? Though there is immense institutional inertia in favour of the incumbent carbon-based regime, the confluence of production costs, clean energy sector progress, and the emergence of climate change as a major political issue suggests that we may be approaching a tipping point (Jaccard et al., 2018). Financial actors will play a key role in the path we follow, as this transition is not a technical question but a profoundly social and political one.

Within this context, the heightened risk of asset stranding in the fossil fuel industry and increased commitments to decarbonization suggest there is a case for radical intervention to mitigate the financial and reputational risks associated with climate change. Niche innovation in sustainability-

oriented finance that constrains fossil fuel production will play an important role in a low-carbon transition by both reducing the environmental risk and the negative impact of resource use through supply-side constraints and systematically limiting the exploration, extraction, or transportation of fossil fuels (Kemp & Pearson, 2007; Ryszawska, 2016).

Grounded in the adaptive expectations theory (Arthur, 1989; Pierson, 2000), it is possible to infer the credibility of a carbon-constrained future (Strauch et al., 2020). Self-reinforcing expectations-commitment cycles require actors to select between two potentially diametric futures. We argue that the uptake of divestment, net-zero, and voluntary commitments like the Task Force for Climate-Related Financial Disclosure and Glasgow Sustainable Finance Alliance indicates a shift in thinking among financial actors toward a carbon-constrained future. We see a similar shift within the energy sector as well; the International Energy Agency's Net Zero by 2050 roadmap is unequivocal that there must be a significant decline in fossil fuel production to limit the global temperature rise to 1.5 °C (IEA, 2021).

Nevertheless, production and emissions continue to rise. Global emissions have surged faster than expected in the last year, rebounding back to pre-pandemic levels (Friedlingstein et al., 2022). Under the current trajectory, humanity will surpass the global carbon budget required to mitigate warming under 1.5°C in the next 11 years. Many financial actors similarly remain locked into the incumbent paradigm. Since the Paris agreement, banks around the world have lent a total of 3.8 trillion dollars to fossil fuel firms globally; Canadian banks alone have lent over 900 billion (Rainforest Action Network, 2021). Pension funds similarly maintain large investments in the fossil fuel industry; Canadian pension funds have increased investments in fossil fuels firms by 17 percent since the Paris agreement, from 9.9 to 11.6 billion dollars (Dempsey et al., 2021).

The call for action is ambitious but feasible with concerted action. This will require all actors to align their actions with a carbon-constrained future. Capital markets, through their function of resource mobilization, are particularly influential actors. We assert that those actors who fail to align with a carbon-constrained future must be held accountable for the climate instability caused by their actions.

1.5 Research Questions

Broadly, this research examines the potential influence of incumbent shareholders in driving a low-carbon transition in the fossil fuel industry. Typically, discourse on capital investments revolves around the reallocation of funds from polluting to non-polluting industries (Bolton & Foxon, 2015; Hafner et al., 2020; Zhang, 2020). However, there is a gap in the influence of incumbent investors in enabling a low-carbon transition within the fossil fuel industry. We thus ask, can capital markets play an enabling role toward a low-carbon transition in the fossil fuel industry? We present the sub-research questions below.

1.6 Organization of the Thesis and Sub Research Questions

Chapter 2 begins with a broad review of sustainability management research to date. The question remains if the case for strengthening the role of corporations in tackling grand challenges like climate change is clear, why do organizational activities continue to fall short? We argue that conventional management research, including management theories, is unsuitable for meaningfully addressing grand societal challenges and assert that to address these challenges, a new transdisciplinary research agenda, grounded in ontological framings and process-oriented outcomes, are required to move beyond the mechanistic and reductionist theories of management

studies. To do so, we explore how sustainability management, as a distinct research paradigm, has differentiated itself over the past 70 years of management research through language, methods, theories, and relevance to the sustainable development goals.

Chapter 3 hones further on existing literature on shareholder interventions in the fossil fuel industry. Recognizing the immense influence of capital markets in enabling or hampering sustainability transitions through functions of resource mobilization, this research asks how existing literature delineates investor responsibilities on climate action. Specifically, we examine two diametric interventions, divestment and engagement, to evaluate where the literatures overlap and how the fields compare with respect to discourse on climate change and fossil fuel production. We assert through this review that engagement research remains largely silent on discourse on fossil fuel production and climate change and argue that this is in part due to myopic theoretical foundations based on profit maximization. Consequently, literature on the impact of shareholder engagement does not consider the role of shareholders in inciting a managed decline of fossil fuel production in line with the low-carbon transition.

Chapter 4 consequently turns to a national study to identify who the most influential shareholders are in Canada's fossil fuel industry and how sensitive the industry is to shareholder influence. Founded in agency theory, the study articulates that large shareholders can influence the fossil fuel industry to influence corporate governance; however, the question remains, would shareholders use their influence to restrict emissions? We find that ownership in Canada's fossil fuel industry is highly leveraged and highly concentrated – and thus are more susceptible to shareholder intervention. However, insights on proxy voting indicate that investors may not be meaningfully engaging with the fossil fuel industry. We assert that agency theory is inadequate in explaining why major shareholders do not effectively engage in the fossil fuel industry. However, the capital

as power theory asserts that investments are a forward-looking indicator of future profit, and consequently, investors may be motivated to maintain favourable market conditions for their firms to mitigate against the financial risks of stranded assets. Capital may thus be used in a manner that contradicts effective climate solutions if those interventions are perceived to be of material financial risk to the investor or to the stability of the industry.

Chapter 5 finally looks globally at the 200 largest publicly traded oil, gas, and coal firms. It is anticipated that, if burned, the reserves held by these 200 firms would surpass the global carbon budget three times over. It is thus essential that we identify which shareholders can influence the industry and hold them accountable for propping industries attributed to climate instability. We thus ask, how much influence do equity owners have over the governance of the industry and who are the equity owners that have the greatest potential impact? Theoretically, the multi-level perspective of transitions is used to explain how niche innovation in capital markets, driven by changes in social landscapes of policy and culture, can disrupt the incumbent regime of carbon-based energy production. The results not only assert that financial markets can influence the trajectory of sustainability transitions as enablers for socio-technical transitions but also exemplify that power is concentrated among just a handful of powerful and path-dependent financiers. Voluntary commitments and policy interventions may lead to radical innovation in capital allocation processes through the process of creative destruction.

2. MAPPING 70 YEARS OF ADVANCEMENTS IN MANAGEMENT RESEARCH ON SUSTAINABILITY

This chapter is adapted from: Dordi, T., & Palaschuk, N. (2022). Mapping 70 Years of advancements in management research on sustainability. Journal of Cleaner Production, 132741.

2.1 Introduction

In the last decade, 'grand challenges' (GCs) have become an increasingly attractive entry point for management scholarship to conduct pragmatic and action-oriented research that bridges the business-society-nature interface (Marcus et al., 2010). According to George et al. (2016), GCs may be defined as "a specific critical barrier(s) that, if removed, would help solve an important societal problem with a high likelihood of global impact through widespread implementation" (George et al., 2016, p. 1881).

What some scholars refer to as the 'greatest challenge' facing management research, the ever-widening research-practice gap, becomes notably extended as businesses continue to underestimate the interconnectivity and urgency associated with GCs (Banks et al., 2016; Bansal & Hoffman, 2012). This underscores the lingering need for new ontological framings of GCs that move beyond mechanistic and reductionist research paradigms, to deepen understandings of 'how' and 'why' proven strategies for addressing GCs can be successfully transferred, scaled, and sustained across dynamic and emerging landscapes (Rynes & Bartunek, 2017). The authors posit that for solutions to become more actionable, a new transdisciplinary research agenda is required.

As an evolving field of research and practice, Sustainability Management (SM) embodies a functional response to the historical limitations of siloed (sustainability; management) sciences and their capacity to help businesses navigate dynamic, uncertain transition processes (Williams et al., 2017). Rather than a GC in-of-itself, the authors hold that 'sustainability' provides a research

paradigm (by which scholars perceive and act on GCs) that, when embedded into management language, theory, and method, provides a systems approach to drawing interconnections between business activities and GCs, spanning organizational boundaries and traditional stakeholder groups (Dyllick & Muff, 2016; Gladwin et al., 1995).

This study aims to explore how sustainability, as a distinct research paradigm within management research, is reflected in the research discourse of top business and management journals and whether and how this framing more effectively targets the GCs of today. This review is the most extensive study of its kind on SM literature, collectively screening 46,856 publications across 27 top management journals. Using novel computational advancements in text mining, mapping, and visualization, this review outlines past and emerging research foci, key shortcomings and conceptual gaps in SM thinking, highlighting opportunities to integrate and expand on existing discourse. There remains immense potential to synthesize findings of individual studies to advance scholarship on SM as a stand-alone field of study. This review concludes by identifying four avenues for future research to advance the study of SM; under the umbrellas of language, method, theory, and the operationalization of GCs.

2.2 Literature

Building upon existing strengths and bringing together traditionally separate research agendas, the authors advocate for SM as a transdisciplinary framing capable of supporting future management research in its capacity to inform evidence-based practice as deemed necessary to support organizations in tackling grand societal challenges (Briner et al., 2009; Laasch, Moosmayer, et al., 2020; Rousseau, 2012; Rynes & Bartunek, 2017).

Issues of sustainability have become increasingly salient across management literature. The topic has been approached through various foci, including climate change (Chandy et al., 2019; Wright

& Nyberg, 2017); education (Muff et al., 2017; Waddock, 2020); resilience (DesJardine et al., 2019; Hamann et al., 2020); responsibility (Laasch, Suddaby, et al., 2020; Voegtlin et al., 2019); ethics (Martí, 2018); paradox (Schad & Smith, 2018); systems thinking (Bansal, Grewatsch, et al., 2020); and sustainable development (Howard-Grenville et al., 2019). Admittedly still a nascent and emerging body of knowledge, management research on GCs are inherently confined to specific areas of study, with sustainability framings constituting but a minor proportion of total research outputs (Aguinis et al., 2020; Hamann et al., 2020). For solutions to become more actionable, a new language and broadened participation is required, engaging a range of disciplines, and theoretical and methodological approaches across multiple levels of organization and society in the form of SM (Starik & Kanashiro, 2013).

Grand challenges have been adopted as a moniker by management researchers when examining the role of political, institutional, and social structures and their relative contributions to the persistence and attenuation of deleterious effects on socio-ecological functioning (George et al., 2016; Howard-Grenville et al., 2019; Wright & Nyberg, 2017). While constituting systemic global problems, requiring collective action to sustain widespread implementation, these challenges are experienced locally and contextually nuanced (Berrone et al., 2016). Characterized by their complexity, uncertainty, and normativity (Ferraro et al., 2015), the capacity for research to devise meaningful solutions lie in their ability to drive behavioural change and socio-technical transitions. While theoretically robust and responsible for providing important scientific insights and helpful recommendations for practice, the current state of affairs constitutes a dangerous trap of incrementalism and impedes timely progress towards fulfilling societal needs.

Grounded in normative principles of human behaviour, organizing, and managing, the goal of SM is to continuously enhance the ability of individuals, organizations, and societies to experience

benefits from natural and socioeconomic systems (Williams et al., 2017). Compared to previous iterations of managerial sciences, the field of SM research represents a key departure in theoretical logic, moving past historical patterns that are narrowly human elite-dominated, bound by siloed thinking (Gladwin et al., 1995). If viewed as a compilation (that being one where SM is a complex combination of the contributions of lower-level management and sustainability research field), then SM provides the applied lens necessary for progressing management discourse through the translation of sustainability criteria into political, institutional, and behavioural reform (Molina-Azorín et al., 2019; Williams et al., 2017).

Linnenluecke and Griffiths' (2013) study on the origins and structure of the corporate sustainability field is among the few cross-cutting bodies of research to date, providing analysis on sustainability-related trends and themes. Taking a broader definition of sustainability (to include topics related to responsibility, responsiveness, and greening, among others), they clustered the field into four distinct conceptual genealogies: corporate social performance theory, stakeholder theory, a corporate social performance versus economic performance debate, and a greening of management debate. Williams et al.'s (2017) study on systems thinking and SM similarly adopts a cross-cutting approach to SM research; using a 'systems' lens, the authors delineate core fields for future research, including behavioural change; leadership; industrial ecology; socio-ecological systems; transitions management; paradigm shifts; and education. The authors go one step further to suggest that these areas of research hold shared principles of interconnectivity, feedback loops, emergence, and self-organization (Williams et al., 2017). While previous iterations of management theory do not focus on sustainability and in doing so, fail to address GCs (i.e. Sustainable Development Goals), management theories do hold an advantage over organizational theories in that management can be performed at multiple levels, from the

individual through organizational to societal levels. Thus, as noted by Starik and Kanashiro (2013), it may be a worthy endeavour to explore which management theories can be used to advance the evidence-based practice(s) as part of this field.

The objective of this paper is thus to present the current state of academic discourse on SM to provide insights into current focal areas of research discourse, how it differentiates itself from 'conventional' management (CM) literature, and where it should go over the next crucial decade of action on GCs. This objective is achieved over three steps. First, this paper examines each subfield of SM and CM independently and over time to present historical research agendas and future avenues for research. Second, this paper compares SM and CM literature to identify how the two subfields differ. Finally, a deductive analysis of grand challenges and theories helps highlight research agendas where each field can develop over the next decade.

2.3 Data and Method

This research adopts a mixed approach to the content analysis methodology combining inductive, deductive, and comparative elements to garner insights into how sustainability literature has evolved over time and in relation to management literature (Creswell, 2014; Elo & Kyngäs, 2008; Hsieh & Shannon, 2005). By identifying nascent and latent trends in sustainability discourse within management literature, this research contributes to existing literature reviews in this space. Unique to this study is the scope of literature examined; reviews to date largely remain siloed within the subfields of management studies (Johnson & Schaltegger, 2016; Martins et al., 2019; Rajeev et al., 2017; Silvius & Schipper, 2014). This underscores the lingering need for a deeper review on sustainability within the broader scope of management literature that might inform the future development of the field. By adopting novel advancements in computing, big data, and research

mapping to inform the positionality of sustainability in management studies, a new research agenda on sustainability and GCs are clarified as a call to action for the next crucial decade of the SDGs. This study advances existing literature and differentiates itself in three regards; first, this is one of the most extensive reviews of its kind on CM and SM literature, collectively examining 46,856 articles; second, this is one of the first papers of its kind to incorporate a novel interdisciplinary research mapping technique to compare theoretical, methodological, and practical approaches prevalent in SM versus CM management; and third this is the first paper to frame SM as capable of bridging traditionally siloed sustainability and management research, as deemed necessary to inform evidence-based practice on GCs.

Data Collection

To ensure validity and replicability, this study drew the sample for analysis based on Marrone and Linnenuecke's (2020) methodology. In line with Maronne and Linnenuecke's (2020) study, this paper sourced management literature through the Scopus database, selecting articles published in the business, management, and accounting subject area. This specific database was selected due to its broad coverage and advanced search capabilities, which resultantly enhance the inclusivity of the dataset. Table 2-1 presents a flowchart of the data collection process. Collectively, Scopus indexes 1,702 journals under this subject area. Exclusionary screening criteria were based on the CiteScore methodology, which provides an indication of research impact. The Scopus 'CiteScore' is measured by the citations received over a 4-year publication window divided by the number of publications published over the 4-year window. For this study, the top three journals for each sub-field under the 'Business, Management, and Accounting' header were selected. This included; 1) Accounting, 2) Business and International Management, 3) General Business, Management and

Accounting, 4) Industrial Relations, 5) Management Information Systems, 6) Management of Technology and Innovation, 7) Marketing, 8) Organizational Behavior and Human Resource Management, 9) Strategy and Management. In line with Marrone and Linnenuecke's (2020) methodology, this paper excluded the Tourism, Leisure and Hospitality Management subfield due to its narrower focus as well as the Business, Management and Accounting (miscellaneous) category due to its non-classified focus. Thus, 27 journals (presented in Table 2-2 below) were included under the business, management and accounting subject areas. In line with exclusionary screening measures, duplicates and manuscripts that do not include key metadata, including title, author, journal, abstract, keywords, and year, were removed. In instances where a journal may be among the top three in more than one subfield, the journal was selected based on its percentile rank, provided by Scopus. The *Academy of Management Journal*, for instance, though ranked third under Strategy and Management, ranks first in General Business, Management and Accounting and is consequently allocated to the latter. In this instance, the next top journal (in the Strategy and Management sub-field) was subsequently selected by CiteScore (i.e. *Strategic Management Journal*). The resulting sample included 46,856 articles, spanning from as early as 1946 (*Journal of Finance*) to December 2020.

Table 2-1 Flowchart of Journal Identification and Data Processing

Journal Identification and Screening	1. Identify Scopus Indexed Business, Management and Accounting Journals.	1,702 Journals
	2. Exclude for top journals by sub-field (9 subfields) and CiteScore (top 3 ranked journals)	27 Journals
Article identification and screening	3. Download article metadata from journals, including title, abstract, keyword, year, and author, for all years.	46,856 Articles
	4. Check for duplicates (none found)	46,856 Articles
Data Processing	5. Combine articles into one dataset and clean data by formatting titles, journals, and authors for consistency	
	6. Delineate sustainability keywords by whether SUSTAINA* appears in the title, abstract, or keywords	
	7. Combine author and Scopus-associated keywords, and clean data by removing white space and punctuation. Exclude terms that appear in journal titles from the keyword search and combine similar keywords.	

This table presents a flowchart of the data collection process, including journal identification, article identification, and data processing.

To differentiate between conventional and sustainability-related articles, the authors delineate 'sustainability' literature based on whether the root word 'SUSTAINA*' appears in an article's title, abstract, Scopus-associated keywords, or author keywords. A total of 800 articles matched the search term.

Of note, it is not the purpose of this paper to qualify whether the 800 articles that speak to sustainability meet the criteria of SM research outlined in previous reviews (Hörisch et al., 2014; Ozanne et al., 2016; Starik & Kanashiro, 2013; Williams et al., 2017). In parallel, this review does not set out to delineate the heterogeneity in sustainability-related terminology being operationalized by management scholars; a long-standing critique of sustainability literature, this would, however serve as a fruitful line of future inquiry. In preparing the data for analysis, data was cleaned by grouping similar terms, and removing punctuations, numerical values, abbreviations, and parentheses. Highly similar duplicates were also manually clustered together. For example, 'sustainable supply chain management', 'supply chain management', 'supply chain', and 'supply chains', were grouped under 'supply chain management'. In all, the sample contains 70,208 unique keywords.

The analysis was conducted using R, with several notable packages. Data loading of the BibTeX files is undertaken using the Bibliometrix package (Aria & Cuccurullo, 2017), data cleaning and content analysis is conducted using the tidytext package (Silge & Robinson, 2016), visualizations are created using the ggplot2 package (Wickham, 2009), and the analysis of categorical data is conducted using the vcd package (Meyer et al., 2017).

Method

This paper adopts a mixed-methods approach to the content analysis (Hsieh & Shannon, 2005), combining inductive, deductive, and comparative elements to garner insights into how SM literature has evolved over time and in relation to CM literature (Elo & Kyngäs, 2008). This summative approach to content analysis goes beyond mere word counts to include latent content analysis, the process of interpretation of hidden trends.

The analysis begins with an inductive term frequency analysis, which provides insight into prominent terms and concepts within each subsample (Silge & Robinson, 2016). The subsequent burst detection analysis extrapolates on the word frequency analysis by tracing the evolving interest in themes and content over time (Kleinberg, 2002). This can inform researchers about whether a topic is of nascent, developed, or declining interest in CM and SM research. Consequently, the burst detection analysis addresses the first research objective, to examine historical research agendas and future avenues for research within CM and SM literature.

'Bursting' topics were identified using the Poisson burst detection algorithm (Khaing & New, 2017). This burst detection methodology has previously been applied in the context of natural disaster management, employee engagement in sustainable organizations, and in natural language processing (Buscaldi & Hernández-Farias, 2015; W. Kim et al., 2016; Sohrabi et al., 2019), to identify periods where keywords are of increasing interest – measured as abnormal spikes in the frequency of a keyword over a fixed period. Keyword use is often used as an indicator of trends in research output during a specific time period, whereby changes in keyword diversity and frequency can signal future research synergies between CM and SM sub-fields (Palaschuk & Bullock, 2019). Specifically, abnormal deviation in keyword use is measured at a point in time relative to its

average frequency over a three-year window. This technique allows us to detect 'bursts' of interest in select keywords over time and infer thematic changes in research foci.

The burst detection analysis is complemented with an inductive interdisciplinary research mapping technique by Mutz et al. (2015) and Marrone and Linnenluecke (2020), used to conduct a comparative analysis between CM and SM literature. The burst detection analysis addresses the second research objective, to identify how the two subfields differ.

Similar themes can highlight key areas of overlap (i.e. thematic, theoretical, methodological) that, if built upon, can help scope emerging research agendas and, in turn, support a systems perspective and shared language spanning disciplinary boundaries (Bansal, Grewatsch, et al., 2020). Oppositely, disparate themes inform researchers of lingering (knowledge) gaps and where opportunities for future and thematic synthesis may lie. Keywords are distributed by proportional frequency over a scatterplot, where the x and y-axes correspond to word frequencies in CM and SM literature, respectively. A Pearson moment correlation test is applied here to test for correlation between SM and CM-related keywords.

The final research objective is addressed with a deductive frequency analysis examining whether and how SM versus CM literature differ in their use of theory and on the sustainable development goals. First, a search for keywords that included the root word THEOR* was conducted, to identify common theoretical frames in CM and SM literature. Top theories are plotted based on their proportional frequency (the number of instances of the keyword divided by the number of articles in the SM and CM corpus, respectively). This deductive analysis informs us about what types of theoretical perspectives SM and CM adopt to inform their work. Second, a frequency analysis using the Sustainable Development Goals framework was conducted, to evaluate how SM and CM literature engages with each topic. Keywords and synonyms used for each Sustainable

Development Goal in the deductive analysis are delineated in the caption under Figure 2-8. The keyword frequency is plotted based on the proportional frequency of related keywords. To test for variation between the frequency of theories and the sustainable development goals using, the Fisher exact test of non-random association was used. The effect size of the association is measured using the Cramer's V, and Pearson residuals are applied to identify the deviation of the expected and observed values for each category.

Limitations

Foremost, this paper is not a systematic literature review, but rather a content analysis of keywords found in top management journals. This quantitative content analysis methodology has been used in previous studies like Moldavska and Welo (2017), Wiese et al. (2012), and Eichler and Schwarz (2019). By primarily examining the content using keywords, this research is able to meaningfully utilize the computational capabilities of the R software to present broad results across large swaths of data. However, this method reduces the researcher's ability to analyze nuance when compared to an in-depth review. The aim of this analysis is, thus, not to delineate what management research is saying about sustainability but to provide insight into the breadth of sustainability themes that are receiving attention. Future research can build upon this study by systematically reviewing sustainability management subthemes for more nuanced reviews.

On data collection, the authors acknowledge some additional limitations. First, this research only uses the Scopus database to identify journals of interest. The authors justify this choice by asserting that Scopus is among the most comprehensive databases for management literature, indexing the most prolific journals in this research space. Scopus is also the primary source for Marrone and

Linnenluecke (2020) study, whose methodology is replicated here. Finally, given the scope of the sample size, to extend beyond Scopus would provide little additional insights.

It is worth nothing however, that the selection of journals by impact factor does have its limitations, one of which being the limited exposure to journals that better align with sustainability research, such as Business and Society, Journal of Business Ethics, and Organization and Environment. However, the authors maintain that for SM research to gain mainstream relevance and be considered sufficiently established as a core research discipline, it must also be prevalent among 'top' journals, extending beyond its contemporary niched and siloed outlets.

Finally, some limitations to data processing and analysis are acknowledged. First, this paper identifies sustainability-related articles as those that explicitly use the root word SUSTAINA*. First, sustainability may be in reference to sustaining business processes rather than social or environmental sustainability. Second, an article may, for example, speak to corporate social responsibility but not mention sustainability; indeed, numerous terms, including select GC, can speak indirectly to SM. To mitigate the potential for perpetuating conceptual ambiguity as it pertains to issues of sustainability as identified by previous research (Bansal & Hoffman, 2012; Bansal & Song, 2017; Hacking & Guthrie, 2008; Hammer & Pivo, 2017), the authors maintain that a narrow focus allows for a clear and consistent delineation between what might be considered to fit within the realm of SM. Conversely, the corpus of articles with the absence of sustainability will be classified as 'conventional management literature' (CM). With respect to the chosen analytic process, quantitative methods may not give a complete picture of the 70,000+ terms but rather illustrative examples of some of the most prominent terms.

2.4 Results

This study identified the features and criteria differentiating SM from CM and employed these framings in combination with existing literature to inform how SM is effective in addressing grand challenges and where the subfield lags. The results help to further corroborate positions forwarded by previous research (Hörisch et al., 2015; Kiesnere & Baumgartner, 2019; Williams et al., 2017) - that SM is a nascent, emerging, and impactful framing by which management scholars can address GCs. Where SM and CM diverge, however, offer prospects for cross-cutting research. The authors consequently put forth a research agenda to delineate where SM literature must go to address the GCs and conclude by calling on top management journals to give even greater merit to SM literature that adopt these features.

Of the 46,856 articles published in the leading business and management journals, 800 (1.71 percent) speak specifically (within their title, abstract, or keyword(s)) to sustainability. The first paper in the corpus that references sustainability dates back to 1960, with Anderson's (1960) publication "Financial Policies for Sustainable Growth" in the *Journal of Finance*. Sustainability, however, does not gain a foothold in management literature until the early 1990s, following an increased international interest in sustainability manifested by, among others, the Brundtland Commission of 1987. Constituting but a minor proportion of total management research outputs, research on sustainability has experienced exponential growth, eclipsing the growth rate in management literature with an average 13.2 percent year-over-year growth since 2000. Within the past decade, SM literature grew from 376 to 800 publications (a 112 percent growth), while management literature concurrently grew by 66.9 percent. Indeed, growth in SM research has outpaced the growth in its conventional counterpart every year since 2010. With an eye towards

the future, as the visual signs of the growing scale and magnitude of GCs protrude into social discourse, this trend should be expected to continue.

Interest in sustainability is not, however, ubiquitous across fields of management. The accounting subfield is, relatively, the least engaged with just 7 (0.08 percent) articles referencing sustainability. Organizational behaviour, general business, and information systems also lag mean publication counts, with 0.33, 1.01, and 1.45 percent of their publications referencing sustainability, respectively. In contrast, technology innovation, industrial relations, and strategy are those most engaged with sustainability, accounting for 3.94, 2.94, and 2.68 percent of publications, respectively. By journal, the *Journal of Supply Chain Management* is the most engaged with sustainability (at 8.54 percent), followed by *Technovation* (at 6.36 percent). Of all journals (27) analyzed as part of this study, just one, the *Journal of Labor Economics* has not engaged with sustainability.

SM research thus remains but a fraction that permeates what is a multidisciplinary body of business and management research. Though small in stature, this emerging field punches well above its weight and appears to be highly impactful (Table 2-2). Though accounting for just 1.71 percent of total articles, SM publications account for 3.22 percent of total citations. Based on aggregated citation counts, SM research has a greater impact than their conventional counterparts across 19 of the 27 journals or over 70% of the sample. A shared tenant amongst academic scholars is the pursuit of high-quality research capable of informing policy and practice. Harmony can be found between self-interest and impact, whereby speaking to sustainability-related principles, scholars can create differentiation and deliver greater societal impact.

Table 2-2 Descriptive analysis of publications and citations by journal.

Journal	Subfield	Total Publications	Total Citations	Sustainability Publications	Sustainability Citations	Top Sustainability Article (Total Citations)
Journal of Accounting Research	Accounting	875	69513	1 (0.11%)	42 (0.06%)	Bushman Rm, 2012 (42)
Journal of Finance	Accounting	5118	613836	3 (0.06%)	105 (0.02%)	Gillan Sl, 2009 (83)
Journal of Financial Economics	Accounting	3150	480488	3 (0.10%)	311 (0.06%)	Krger P, 2015 (190)
Academy of Management Journal	General	1864	387273	16 (0.86%)	2887 (0.75%)	Battilana J, 2010 (1051)
Academy of Management Review	General	1111	302194	13 (1.17%)	4137 (1.37%)	Smith W, 2011ev (1156)
Journal of International Business Studies	General	1499	148319	16 (1.07%)	776 (0.52%)	Birkinshaw J, 1996 (344)
Industrial Management and Data Systems	Industrial Relations	2492	53782	99 (3.97%)	2523 (4.69%)	Yew Wong K, 2005 (526)
Strategic Organization	Industrial Relations	439	13276	12 (2.73%)	434 (3.27%)	Bansal P, 2014 (165)
Journal of Labor Economics	Industrial Relations	840	49122	0 (0.00%)	0 (0.00%)	-
International Journal of Information Management	Management Information Systems	2045	66517	49 (2.40%)	2164 (3.25%)	Kshetri N, 2018 (305)
Journal of Supply Chain Management	Management Information Systems	527	29399	45 (8.54%)	4730 (16.09%)	Pagell M, 2009 (820)
Knowledge-Based System	Management Information Systems	4809	120316	13 (0.27%)	734 (0.61%)	Li Hz, 2013 (334)
Academy of Management Annals	International Management	200	18996	5 (2.50%)	1019 (5.36%)	Jackson Se, 2014 (350)
Entrepreneurship Theory and Practice	International Management	947	82320	23 (2.43%)	1823 (2.21%)	Le Breton-Miller I, 2006 (443)
Journal of Business Venturing	International Management	1270	158175	27 (2.13%)	5245 (3.32%)	Dean Tj, 2007 (568)
Journal of the Academy of Marketing Science	Marketing	1933	162972	24 (1.24%)	3586 (2.20%)	Baker We, 1999 (1012)

Journal of Marketing	Marketing	1100	223556	18 (1.64%)	2985 (1.34%)	Vorhies Dw (727)
Journal of World Business	Marketing	1052	55267	44 (4.18%)	2749 (4.97%)	Linnenluecke Mk, 2010 (340)
Annual Review of Organizational Psychology and Organizational Behavior	Organizational Behaviour and Human Resource Management	144	7574	2 (1.39%)	239 (3.16%)	Rupp De, 2015 (125)
Leadership Quarterly	Organizational Behaviour and Human Resource Management	1390	111962	8 (0.58%)	1278 (1.14%)	Gardner Wl, 2005 (794)
Personnel Psychology	Organizational Behaviour and Human Resource Management	2419	143567	3 (0.12%)	107 (0.07%)	Caligiuri P, 2013 (100)
Journal of Management	Strategy and Management	2205	280309	27 (1.22%)	6156 (2.20%)	Aguinis H, 2012 (1361)
Journal of Operations Management	Strategy and Management	1391	142022	50 (3.59%)	7263 (5.11%)	Linton Jd, 2007 (953)
Strategic Management Journal	Strategy and Management	2935	541499	98 (3.34%)	32738 (6.05%)	Teece Dj, 2007 (4364)
International Journal of Management Reviews	Management of Technology and Innovation	460	41438	12 (2.61%)	1992 (4.81%)	Bontis N, 2001 (705)
International Journal of Project Management	Management of Technology and Innovation	2520	111123	54 (2.14%)	2954 (2.66%)	Zou Pxw, 2007 (415)
Technovation	Management of Technology and Innovation	2121	84319	135 (6.36%)	7049 (8.36%)	Caloghirou Y, 2004 (551)

This table presents the final sample of publications by journal and subfield. In instances where a journal ranked among the top three in more than one subfield, the journal is allocated to the subfield with greater fit (based on the Scopus category rank). Total citations, total publication citations, and total sustainability citations are also presented by journal. Finally, the top cited sustainability article from each paper is cited, if available.

Evolution of Management discourse

Beginning with the first research objective, the observational analysis examines the evolution of top keywords within each corpus independently, through a keyword frequency analysis (Figure 2-1 and Figure 2-2). Closer inspection of top keywords in each corpus affirms that the two share many similarities; SM and CM samples share seven of the top ten keywords in each corpus. Expanding on these similarities, four emergent themes were identified based on converging keyword foci. This includes 1) role of technological-side solutions (data mining; artificial intelligence; information technology, technology transfer; research and development management); 2) systems of knowledge creation and use (information management; knowledge management; learning systems; knowledge-based systems); 3) circularity and business model innovation (supply chain management; industrial management; industrial economics); and 4) persistence of business case logic (competition, marketing, performance, competitive advantage). Word frequencies, however, provide a static look at the field.

Figure 2-1 Frequency of Top Keywords from Conventional Management Literature

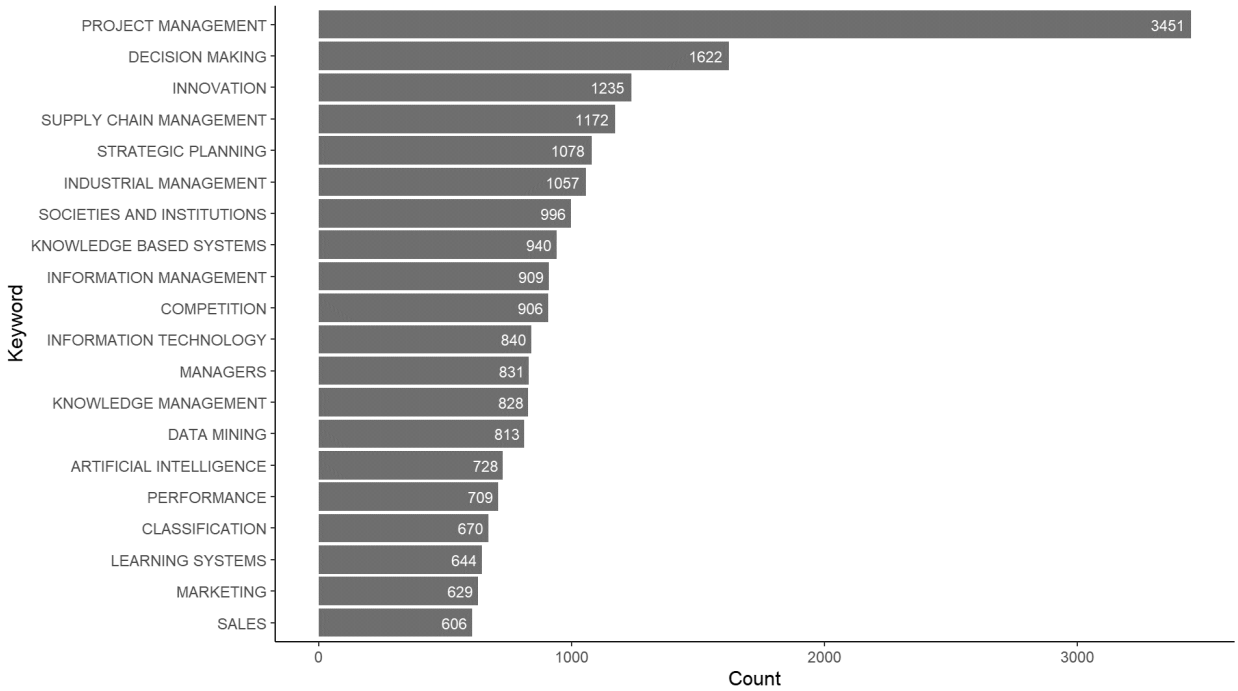
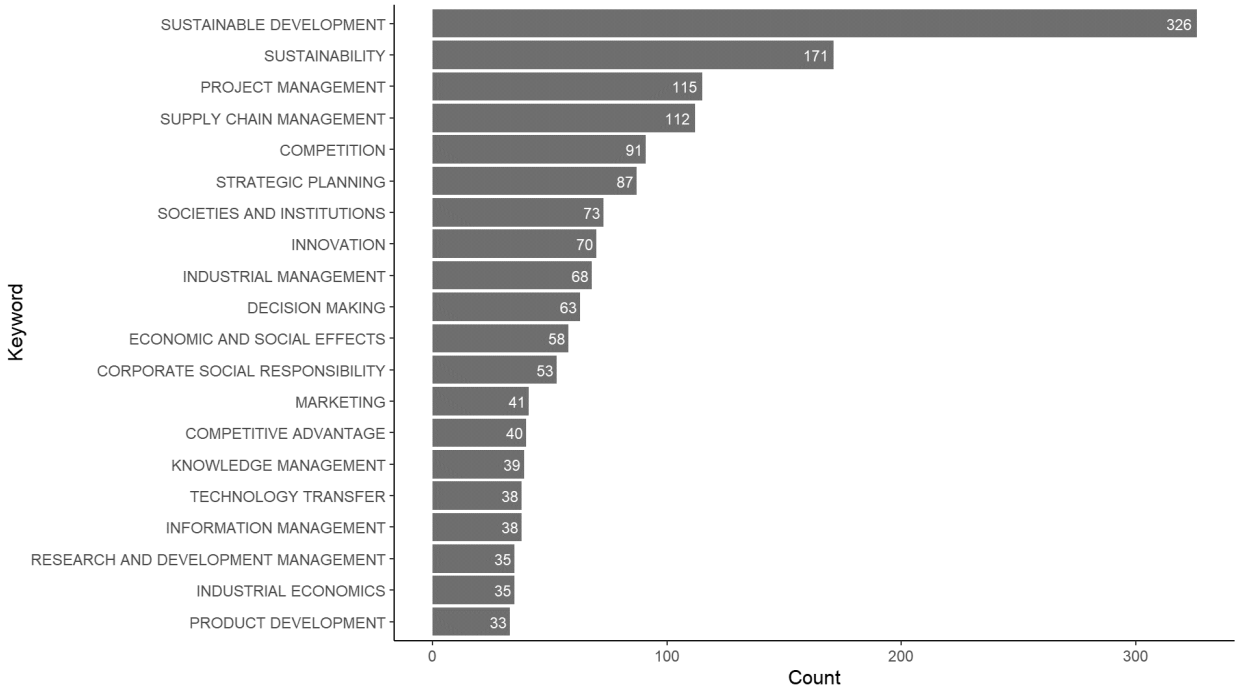


Figure 2-2 Frequency of Top Keywords from Sustainability Management Literature



Author and Scopus associated keywords are combined and counted by frequency. The top 20 keywords are sorted by frequency and mapped on the y-axis. The frequency by which the keywords appear in each sample (conventional literature and sustainability literature) are presented on the x-axis.

The burst detection analysis extrapolates the word frequency analysis by tracing the evolving interest in themes and content over time (Kleinberg, 2002). This can inform whether a topic is nascent, developed, or declining. Bursting' topics are identified using the Poisson burst detection algorithm (Figure 2-3 and Figure 2-4). On the cusp of CM literature are two prominent trends. First, it surrounds the emergence of big data, deep learning, and deep neural networks and; second the topic related to social media, social networking, and (public) sentiment. In contrast, within the SM literature, discourse around the incorporation of environment and society through topics of corporate social responsibility and triple bottom line was prevalent in the 2010s. Topics of project management and supply chain management, though having a more long-standing history, also gained prominence in the latter half of the 2010s, perhaps due to mounting interest in the circular economy (Korhonen et al., 2018; Murray et al., 2017) and business model innovation (Bocken et al., 2014; Evans et al., 2017; Geissdoerfer et al., 2018). Within the last year, however, systematic literature reviews, risk perception, and blockchain are among the budding topics of interest in SM literature.

Figure 2-3 Burst Detection in Conventional Management Literature

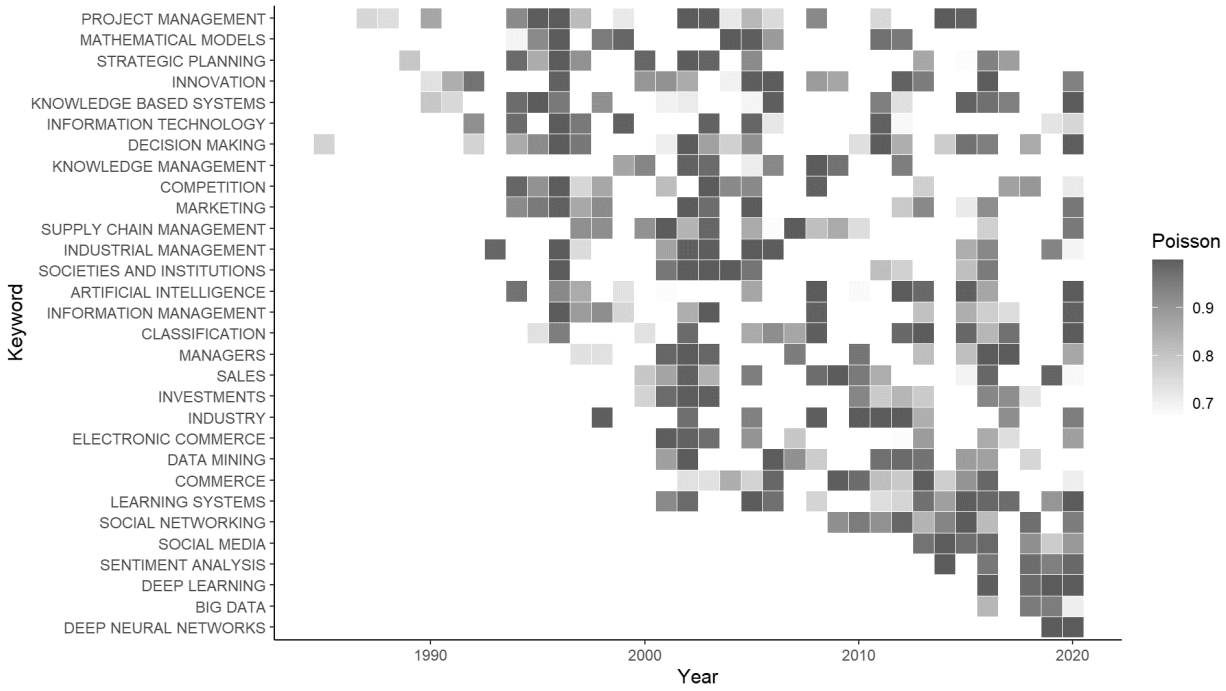
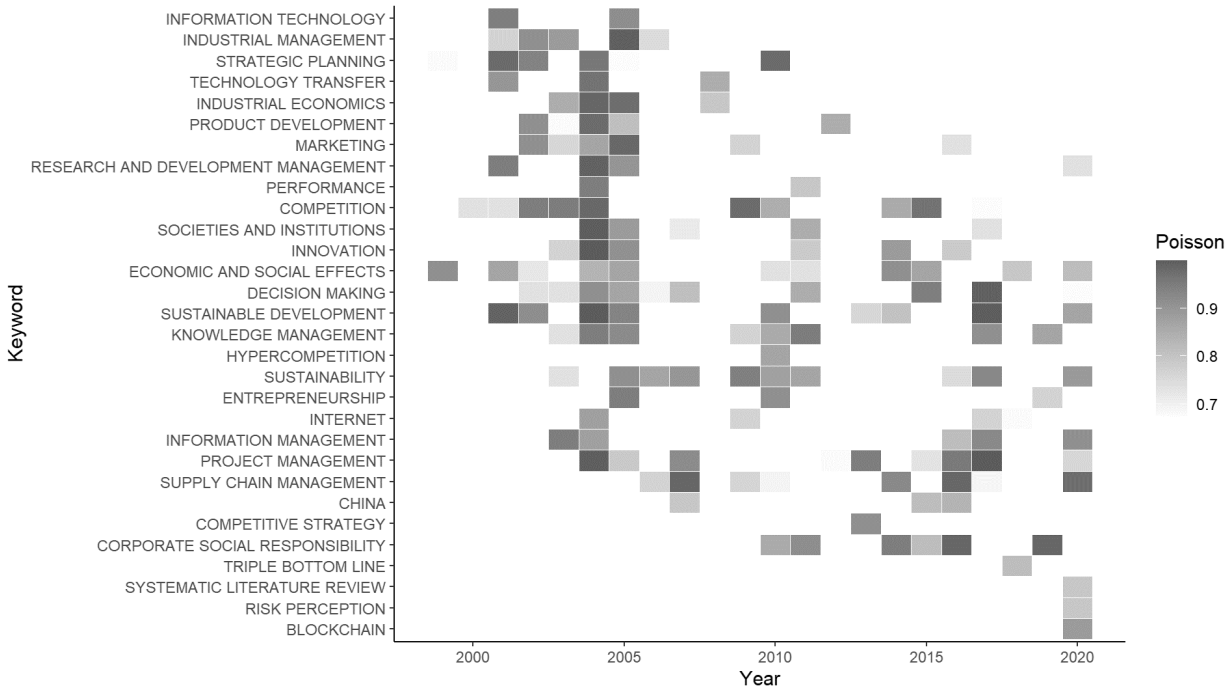


Figure 2-4 Burst Detection Sustainability Management Literature



The Poisson burst detection is used to measure the evolution of keywords in conventional and sustainability management literature. By measuring abnormal spikes (Poisson score greater than 0.67) in the frequency of a keyword over a fixed period, burst detection visualizations are depict inception points, periods of greatest interest, and nascent or future research agendas. 20 keywords that are ranked by term frequency and sorted by time are presented on the y-

axis. The years of greatest interest are presented on the x-axis. The darker shade represents a larger deviation from the mean.

Sustainability versus Conventional Management Language

Though the observational analysis illustrates that keyword usage in SM and CM literature does vary, there is common ground to be found. A Pearson's product-moment correlation test of SM and CM keywords find that the two samples are 79.4 percent correlated ($p < 0.001$). That is, the majority of the (approximately 70,000) keywords being used in SM and CM samples are the same. In examining the second research objective on where they differ, however, a comparative analysis is conducted using the interdisciplinary research mapping technique. The results of the research map are presented in Figure 2-5 and Figure 2-6 below.

While a distinct sub-field of study, SM is still rooted in the language of (conventional) management research illustrated through similarities across keywords. Where SM diverges is its unique focus on real-world pragmatism. Keywords like climate change, agriculture, and ecosystems speak directly to GCs. Reference to the global south, attested by keywords like Brazil, South Africa, and India, further connote a geographical dimension to SM literature. Finally, references to ontological framings, including case studies, content analyses, literature reviews, conceptual frameworks, and action research, speak to a proliferation of grounded approaches to studying SM. Consequently, SM is framed in a way that is more translatable and conducive to addressing the science-practice gap (DesJardine et al., 2019). Acutely noticeable, however, despite the mounting calls by leading researchers (Bansal, Grewatsch, et al., 2020; Williams et al., 2017), is the dearth of systems thinking-related discourse in SM literature. CM literature, in contrast, remains considerably focused on empiricism, which consequently places less emphasis on the complexities of its real-world applications.

Figure 2-5 presents the 'full' interdisciplinary research map, including keywords that appear in up to one percent of publications. To the top right of Figure 2-5, are keywords that frequently appear in both SM and CM literature. Project management and decision-making, for example, are among the most common keywords across both groups. This can be interpreted that project management on average, appears as a keyword in one percent of all publications. Words just below the diagonal line like 'industrial management', 'competition', and 'supply chain management' are also prominent in both fields but appear slightly more frequently in the SM sample. To the top left of the figure are keywords more often associated with CM literature. Here, a prevalence of keywords related to quantitative methods emerges, including references to algorithms, optimizations, classifications, and clustering. Conversely, to the bottom right are keywords more often associated with SM literature. These keywords tend to incorporate more environmental and social aspects, such as environmental impact, corporate social responsibility, and ecology. Finally, the reader's attention can be drawn to keywords related to theory, which predominantly appear to the center of the visualization. Worth nothing, for example, is that agency theory and decision theory (among others) appear above the diagonal line, indicating that they are more prevalent in CM literature. Conversely, the resource-based view is more prevalent in SM literature. Certainly, not all keywords can be visualized in this interdisciplinary research map; however, taking a closer look at more nuanced keywords is worthwhile. Figure 2-6 thus presents a 'zoomed' look at keywords that appear in less than 0.1 percent of publications to provide greater nuance to where future scholars may choose to explore. Seen here for example, is that SM literature (bottom right) has a unique focus on regionalization through reference to Africa, Brazil, and Asia. Relatedly, SM literature places greater emphasis on grounded research, inferred through reference to keywords like literature reviews and case studies.

Figure 2-5 Interdisciplinary Research Map of Keywords

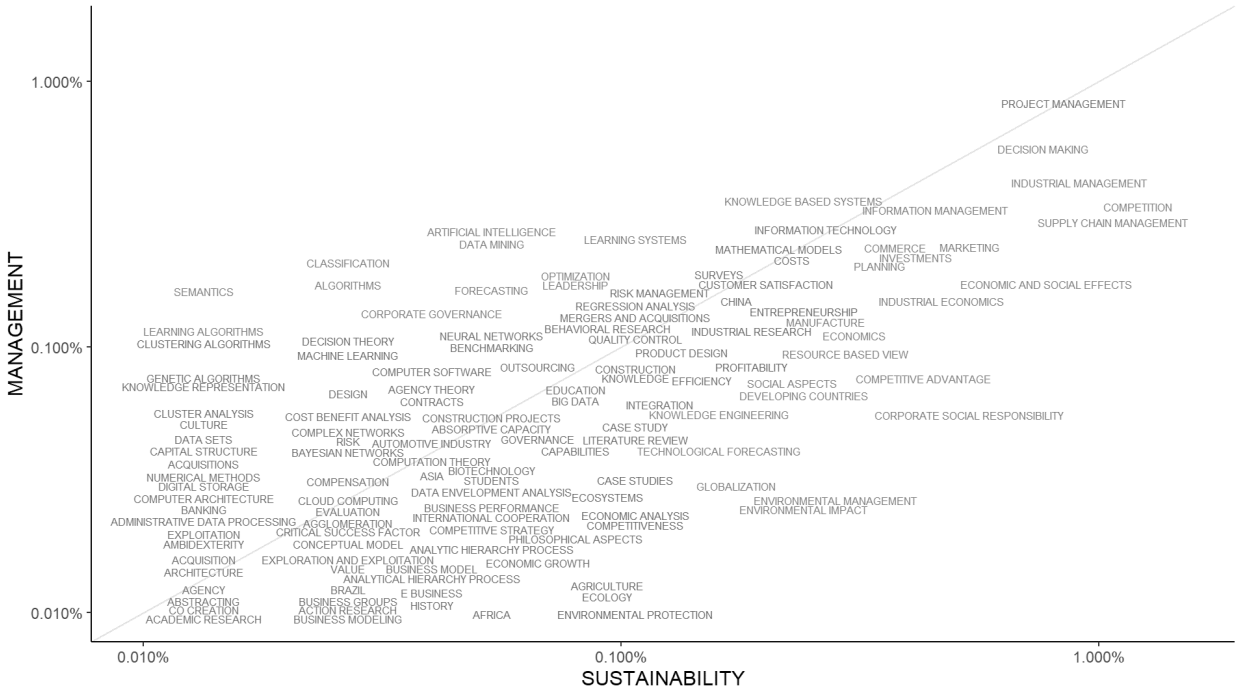
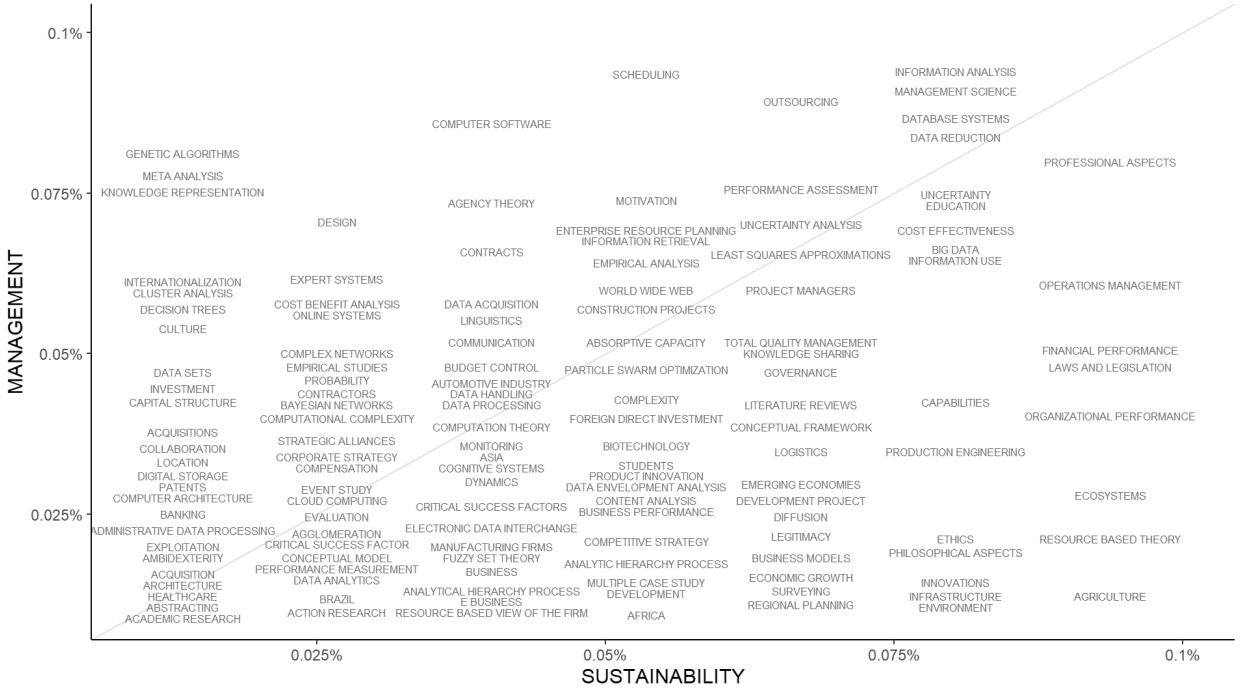


Figure 2-6 Zoomed Interdisciplinary Research Map of Keywords



Interdisciplinary research maps are a tool to bridge disciplinary studies based on similar and diverging keywords. Keywords are distributed by proportional frequency (that is, the frequency of the keyword compared to the total number of keywords) over a scatterplot, where the x and y-axes correspond to word frequencies in conventional and

sustainability management literature, respectively. Words closer to the diagonal line are commonly found in both corpora, while keywords farther away from the diagonal line are unique to one field.

The interdisciplinary research mapping visualizations are complemented with a table of the most common and disparate keywords, calculated as the difference between the proportional frequency of the keyword in CM versus SM literature. Table 2-3 summarizes the keywords most frequently associated with SM literature only, with the CM literature only, and with both bodies of literature equally. Six of the top ten sustainability keywords speak to the environment, suggesting that CM scholars fall considerably short in boundary-spanning research discussing the environmental dimensions associated with business activities. Conversely, four of the top ten management keywords speak to algorithms. SM scholars can incorporate these empirics to help ground abstractions of sustainability, establish verifiable measures of material business issues, and build greater interdisciplinary capacity.

Table 2-3 Unique Words Measured by Relative Distance

Sustainability		**Management**		**Joint**	
Environmental Protection	9.05	Semantics	0.92	Costs	0.01
Environmental Management	8.85	Learning Algorithms	0.89	Risk Assessment	0.01
Environmental Impact	8.12	Classification	0.88	Productivity	0.00
Corporate Social Responsibility	7.98	Clustering Algorithms	0.87	Regulation	0.00
Ecology	6.58	Social Networking	0.87	Software Design	0.00
Stakeholder Theory	6.20	Algorithms	0.85	Finance	-0.00
Agriculture	5.87	Genetic Algorithms	0.83	Least Squares Approximation	-0.00
Environment	5.73	Rough Set Theory	0.83	Computation Theory	-0.00
Blockchain	5.66	Meta Analysis	0.83	Search Engine	-0.00
Infrastructure	4.89	Knowledge Representation	0.82	Absorptive Capacity	-0.00

This table expands on the interdisciplinary research map to presents a list of keywords that are most associated with the sustainability corpus (column 1), keywords that are most associated the management corpus (column 2) and keywords that are commonly associated with both literatures (column 3). The score is calculated as the difference between the proportional frequency value for each corpus.

One common thread is empirics in CM literature versus pragmatism in SM literature. In reference to the rigour versus relevance debate (Gulati, 2007), CM research has prioritized scientific rigour and methodological soundness over strategic relevance and real-world implementability. Vice versa for SM research. The authors believe this either/or debate does little in the way of narrowing the science-practice gap in management research. The lack of empirical studies examining effective management practices along the intersections of sustainable development responsibilities (Van der Byl & Slawinski, 2015) and consistency in how research manages the paradoxical tensions of corporate sustainability trade-offs stands as a significant shortcoming impeding real-world impact (Ozanne et al., 2016). In delineating the differences between the two subfields, however, both sustainability and management scholars alike must target future research toward bridging the gap in grounded empirical research over the next decade.

Given lingering calls for deepening the applied nature to which management research (both in SM and CM alike) provides insights that are translatable to real-world practice settings, it becomes equally important to explore the nature in which research methodologies are being deployed. Not only does the study of methodological trends help provide clarity on which research methods are compatible with different research-practice contexts testing specific hypotheses, and answering research questions, but is of central importance to matching emerging research tools with the appropriate type of grand challenges. In totality, management research becomes better equipped to drive societal progress for the common good in both an effective and ethical manner

Novel methodological approaches utilizing advancements in big data, deep learning, social network modelling, and sentiment analysis are nascent but rapidly evolving in CM literature. Though slower to appear in SM literature, the recent proliferation of systematic literature reviews that utilize bibliometrics, natural language processing, topic modelling, and research mapping

(Bansal, Gualandris, et al., 2020; Linnenluecke et al., 2020) is reinvigorating the means by which research examines large swaths of unstructured texts. The computational capabilities of these tools to unlock insights into latent axiomatic characteristics that envelop the nuances and complexities of sustainability frameworks facilitate new insights that otherwise would not be possible and better equips scholars to conduct research that addresses GCs. It is anticipated that this trend will only accelerate over the next decade through the democratization of open-source data and analytics. Moreover, increased computational capabilities and increased text data availability will inevitably result in a proliferation of publications that utilize these novel methodologies (indeed, this paper does as well).

The question arises to what extent will these methodological advancements drive sustainability analyses; the authors argue the opportunities are only limited by creativity. These methodological advancements arise in cohesion with an increased interest and demand by practitioners for research on reporting and disclosure standards, transparency, legitimacy, and the social license to operate. There is, for example, an opportunity for emerging sustainability scholars to incorporate unstructured text data in the form of company sustainability reports, social media posts, or news articles, to examine corporate social responsiveness to select GCs. Public sentiment data can expose social and temporal dimensions of how GCs are experienced, allowing for the hyper-localization of pragmatic and effective values-based solutions. Using such algorithms to power discourse analysis on sustainability and GCs will allow management researchers and practitioners to better align theory and policy to local needs, values, and resources. However, this is contingent on scholars using these advancements to incorporate complexity, systems thinking, and paradoxical framings in grounding research in real-world pragmatism rather than incremental and reductionistic models. Consequently, the next decade may, in fact, bring increased sustainability-

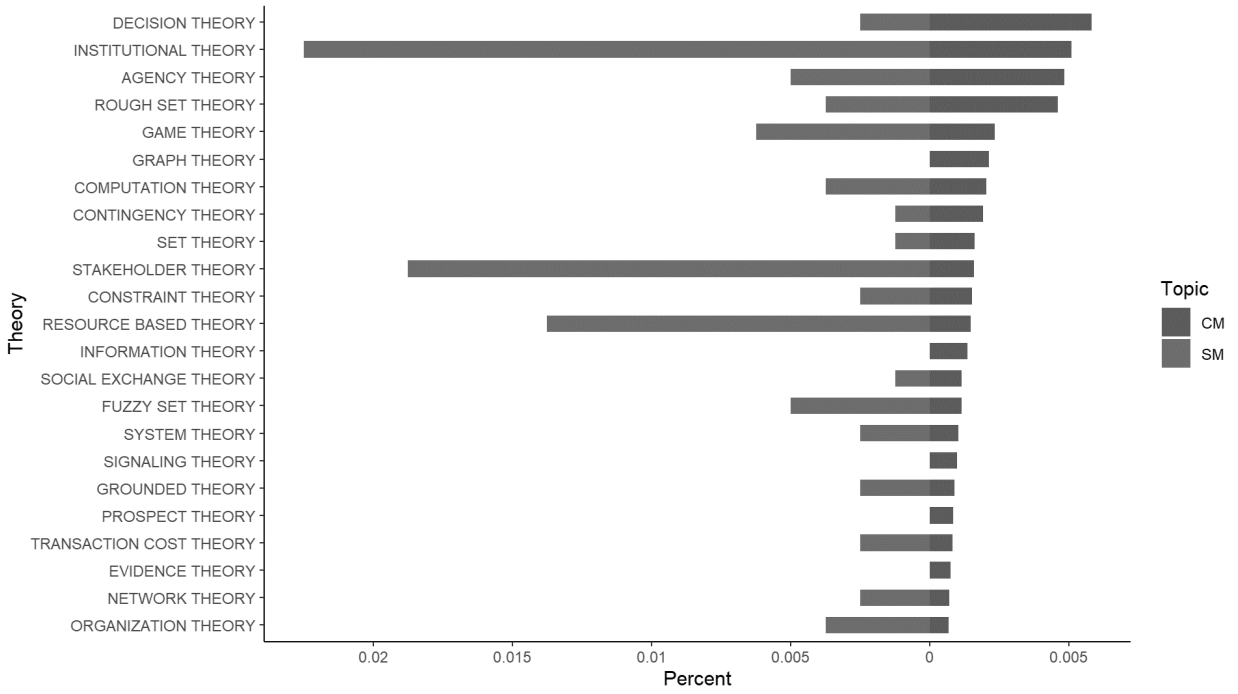
related literature that begins blending qualitative and empirical methodologies, using big data and computational advancements to conduct systematic literature reviews and holistic content and media-driven analyses.

The Future of Management Theory and Grand Challenges

Finally, the discussion pivots to the third research objective on how key theories and GCs can develop over the next decade. Figure 2-7 extrapolates the most prominent theories across SM and CM research. The most prominent theories by frequency in the corpus are Decision theory, Institutional theory, Agency theory, and Rough Set theory. However, the most prominent theories across sustainability literature are Institutional theory, Stakeholder theory, and Resource-Based theory. A simple t-test indicates that the choice of theory does differ between SM and CM samples ($p < 0.001$). A Fisher's exact test for non-random association between categories was performed, indicating that there is again variation between the theory and corpus ($p < 0.001$). Pearson residuals indicate that the variation arises primarily from the prevalence of stakeholder theory and resource-based theory in SM literature.

Attesting to Linnenlueke and Griffiths (2013), institutional, stakeholder, and resource-based theories continue to be among the most prevalent frameworks in SM. Seemingly, little has changed in recent years. This could be, in part, that sustainability is driven less by theory and more by process-oriented outcomes (Starik & Kanashiro, 2013). While these theories have been seminal in scholarly understanding of GCs to date, these decades-old theories cannot be solely responsible for driving research into the future (Ferraro et al., 2015; Hörisch et al., 2014).

Figure 2-7 Top Theories in Sustainability and Conventional Management Literature



Author and Scopus associated keywords that include the word 'theory' are compared between conventional and sustainability management literature. Top theory keywords are sorted by proportional frequency in conventional literature and mapped on the y-axis. The proportional frequency of theories in sustainability management literature is presented to the left of the center.

First, if SM is to fulfill its promise of bridging the research-practice gap in addressing GCs, it must begin by resisting traditional isomorphic tendencies of theory development towards homogenized interpretations. Scholars now point to the legitimacy of emergent hybrid approaches (see the sustaincentric paradigm (Gladwin et al., 1995) and the framework for strategic sustainable development (Broman & Robèrt, 2017) as those most capable of supporting a change in management worldviews deemed essential for collective transitions). If we are to support organizations in their efforts to ramp up the scale and intensity of their sustainability efforts, the imperative for management scholars to question the utility of their research has never been greater. While some point to the historic limitations of academic research in real-world practice settings,

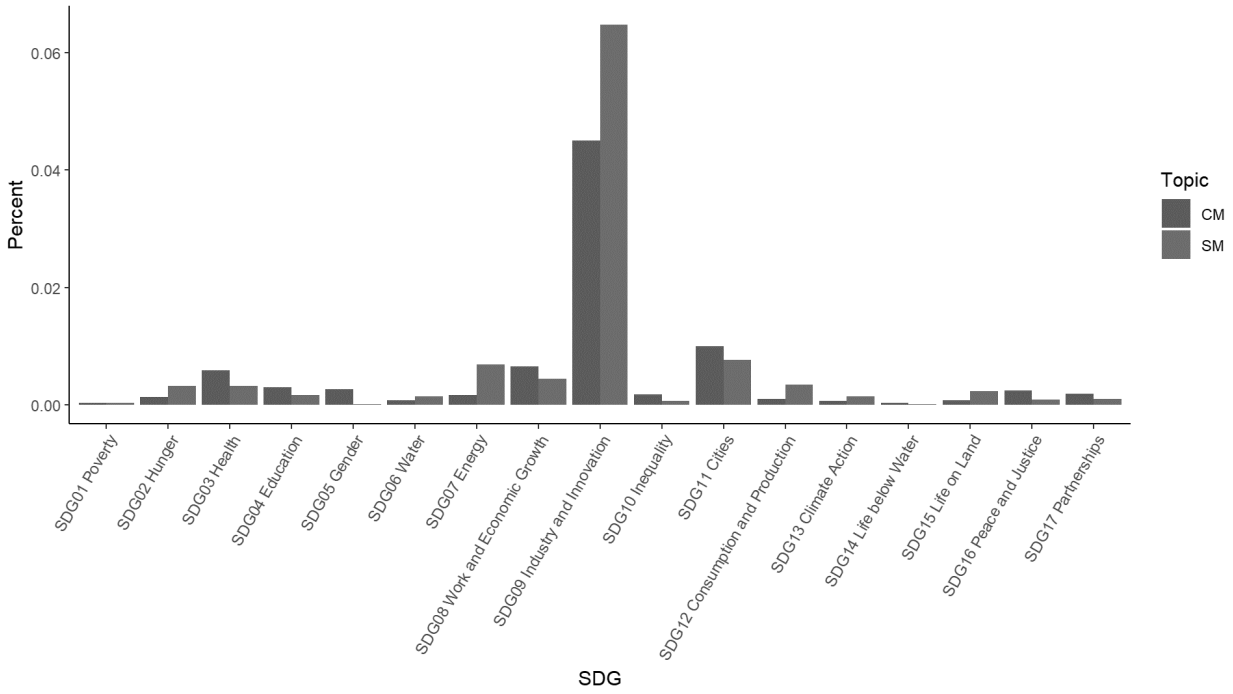
business scholars must strive to contribute timely and practical evidence-based solutions in partnership with private organizations (Starik and Kanashiro, 2013).

Second, SM, as a transdisciplinary school of thought, requires transdisciplinary theories. Currently, management theories are based on a very limited number of disciplines, including primarily neoclassical economics, psychology, political science, business, and public affairs. With the aim of furthering the use of multi-level perspectives in sustainability research (that being one bridging individual, organizational, and societal levels)- this paper provides a disciplinary spanning approach (e.g., management, social, natural) to compile theoretical and methodological approaches best suited to strengthen the translatability of management scholarship.

Hybridization and heterogenization of theory are important to reflect the true complexity, paradox, and trade-offs within decision-making. There is consequently a rich opportunity for emerging scholars to advance theoretical contributions that both further SM as a stand-alone framework of theories while concurrently advancing grounded action on GCs. For sustainability theories to effectively address GCs, the next decade must bring with it new theoretical frameworks that are grounded in complexity and real-world ontologies.

This research concludes by extrapolating the most prominent GCs across SM and CM research, as defined by the Sustainable Development Goals (Figure 2-8). Select synonymous keywords are categorized under each respective goal; SDG3, for example, identifies iterations of health, disease, illness, medicine, mortality, and well* to identify keywords related to health. For comparability, the frequency of each keyword is divided by the total number of articles in each corpus respectively.

Figure 2-8 Top SDGs in Sustainability and Conventional Management Literature



Author and Scopus associated keywords are examined for select words associated with each sustainable development goal. The choice of keywords used for each goal was based on the Scopus SDG query dictionary and the terms are presented below. The 17 goals are presented on the x -axis. The percent frequency (that is, the proportional frequency of articles that included a select term) is presented on the y-axis.

SDG1: pover*, poor, vulnerab*, ^aid; SDG2: food, hung*, ^land, agri*; SDG3: health, disease*, illness*, medicin*, motality, well*; SDG4: school*, educa*; SDG5: gender*, female*, women*, sex*; SDG6: water*, drink*, sanitation; SDG7: energy, electric*, fuel*, grid*; SDG8: "economic growth", "economic development", job*, employ*, ^labor, ^labour; SDG9: industr*, infrastruct*, innovat*; SDG10: equali*, discrim*, migrat*; SDG11: ^city, ^cities, urban, communi*; SDG12: pollution, waste, consumption; SDG13: climat*; SDG14: marine, ocean, ^sea; SDG 15: terrestrial, ecosystem, biodiverse*, specie*, wildlife, fabitat, extinction, deforest*, desertif*; SDG16: peace, war*, conflict*, crime, freedom*; SDG 17: partners*

Perhaps most obvious is the focus on SDG 9 (Industry and Innovation) by both CM and SM literature. Some of the top keywords in this category, across both corpora, include innovation, industrial management, construction industry, and industrial economics. This is followed by SDGs 11 and 8. However, the grand societal challenges (notably elucidated in SDGs 1-6) lag gravely behind. Challenges associated with poverty are those least mentioned across both corpora, appearing just 56 times collectively (less than one percent of the sample). Gender and inequality

similarly appear in less than one percent of sustainability literature. Potentially an outcome that might be expected, the SM niche does discuss environmental factors related to water, energy, climate action, life below water, and life on land slightly more than its conventional counterpart, but lags on almost every social challenge, including health, education, gender, inequality, peace and justice, and partnerships. This result aligns with previous sentiments expressed by Pfeffer (2010) and Lozano and Huisingh (2011) that being there has been an over-emphasis on the environmental dimensions of sustainability at the expense of social issues, which are classified as being poorly developed. A t-test indicates that there is no significant variation in the mean between sustainability and management literature ($p = 0.055$); however, Fisher's exact test does indicate abnormality between the categories ($p < 0.001$). Pearson residuals indicate that the SM literature is significantly more likely to discuss SDGs 2, 7, 9, 12, and 15, but less likely to discuss SDGs 3, 4, 5, 8, 10, 11, 16, and 17 relative to conventional counterparts. In contrast, research within the CM corpus was significantly less likely to discuss SDG 7. Consequently, it appears that both SM and CM literature has failed to appropriately incorporate grand societal challenges into their research. When viewed as a collective body of work, management literature has not been very effective in addressing grand societal challenges. In many instances, SM literature fares even worse than its conventional counterpart. Understanding the roots of this trend can inform future research on this topic and is worth further investigation. One explanation may be that the traditional approach for management has been outwardly focused on environmental impacts, in part because they are more visible and easier to measure; consequently, management literature has neglected the social dimensions of GCs (Pfeffer, 2010). A similar trend is seen in business practices, where externalized environmental factors are given priority over externalized social factors. This raises the question as to whether the operationalization of GCs should be driven by business case or by

obligation. Another possible explanation for the dearth in social GCs literature may be that the majority of research on GCs is conducted by western scholars with a focus on developed economies; it might be assumed that given research on GCs would mirror the broader shift in societal concerns in these economies. As societal GCs are often not experienced to the same degree as they are in the global south; they might not be considered to be (as) material for businesses. Finally, though environmental GCs like climate change have dominated public discourse in recent years, there is an implicit recognition in systems thinking literature that the SDGs are deeply intertwined (Reynolds et al., 2018). Recognizing that action on GCs has feedback loops, decisions can, directly and indirectly, affect a multiplicity of environmental and societal GCs. In review, a revitalized focus on social GCs is needed over the next crucial decade if society is to make progress on the SDGs in an equitable and inclusive manner.

2.5 Discussion

This study presents an overview of the last 70 years of management scholarship to identify how sustainability, as a research paradigm within management research, is reflected through discourse in top business and management journals. The results first attest that SM is a nascent, emerging, and impactful framing by which management scholars can address GCs. Novel methodological approaches within management literature, such as the proliferation of bibliometrics, natural language processing, topic modelling and research mapping (Bansal, Gualandris, et al., 2020; Marrone & Linnenluecke, 2020) is reinvigorating the means by which we examine large swaths of unstructured texts. These methods could be relevant in grounding theory and policy to local needs, values, and resources, to drive localized action on GCs. Theoretically, SM appears to be driven less by theory and more by process-oriented outcomes (Starik & Kanashiro, 2013), and may

thus benefit from drawing from emergent hybrid approaches and transdisciplinary schools of thought. Finally, management literature has not been very effective in addressing grand societal challenges like the Sustainable Development Goals - but in many instances, SM literature fares even worse than its conventional counterpart. The authors thus conclude that for management solutions to become actionable in the face of GCs, there is a critical need to extend a new transdisciplinary research agenda in the form of 'sustainability management'.

3. INVESTMENT STRATEGIES FOR CLIMATE ACTION: A BIBLIOMETRIC ANALYSIS

3.1 Introduction

In light of increasing urgency to mitigate anthropogenic global warming (IPCC, 2022), curtailing fossil fuel combustion – the leading source of greenhouse gas emissions – has gained acceptance as a key intervention point for both state and non-state actors (Green & Denniss, 2018). However, state mitigation strategies alone have proven to be ineffective in deterring fossil fuel combustion (Lazarus & van Asselt, 2018). Current trajectories of fossil fuel production and consumption would surpass the global carbon budget and result in global warming beyond the established safe operating space of 2°C above pre-industrial levels (Matthews et al., 2021).

Consequently, novel forms of non-state interventions from the non-governmental and private sectors have been critical in climate change mitigation efforts. Through direct action, government lobbying, consumer education, engagement, and reputational pressure, these non-state actors have proven to be important catalysts in the low carbon energy transition (Ayling & Gunningham, 2017). One key actor that is frequently overlooked in climate discourse are capital markets (Köhler et al., 2019). Through the mobilization of critical financial resources, capital markets can play a central role in enabling or hindering the low carbon transition.

Capital markets can influence the trajectory of industries that propagate climate instability through one of two mechanisms; divestment or engagement. Though often treated as analogous solutions, there is no review that attempts to bridge these siloed fields of research. This study examines the research trends of each field to pinpoint their genesis, evolution, axiomatic characteristics, and

future research trajectory. Both approaches remain relatively nascent in the literature, and there is no review that attempts to bridge these fields.

The objective of this paper is thus to delineate the two leading tools investors may adopt in response to climate change and bring clarity to how the two compare. The bibliometric method is particularly well suited for this objective as a measure to evaluate scientific literature in a manner that increases rigour and mitigates research bias (Zupic & Čater, 2015). Notably, bibliometric methods are complementary to qualitative structured literature reviews rather than an alternative. This paper is timely in mapping the current state of research on the role of capital markets in enabling or hindering a low-carbon transition. It is particularly well suited for early career researchers and policy makers, as it provides a synthesis of existing trends and a future-looking research agenda given the evolution and trajectory of nascent topics. Thus, this research has notable reference value for future research and practice on climate finance.

The study finds that there is a sizable gap in the literature on the role and efficacy of shareholder engagement in the fossil fuel industry for climate mitigation. It remains unclear which stakeholders can meaningfully engage with the industry, what forms of interventions may influence climate mitigation efforts and the effectiveness of these interventions. There is, thus, a long-term research agenda for emerging scholars on the efficacy of shareholder engagement for climate mitigation.

This paper is organized as follows. The literature review presents a brief overview of the status of scholarship on the role of capital market interventions for climate change. We next describe the methods and data used for this study. The results begin with a quantitative analysis on research progress to date, influential players and papers. We then conduct a content analysis to identify axiomatic characteristics associated with the field of study. The article closes with a discussion of observations and concluding remarks regarding avenues for future research.

3.2 Literature

Though fossil fuel production is the leading cause of anthropogenic climate change (Ekwurzel et al., 2017; Frumhoff et al., 2015b), research and policy in this space remain dominated by demand-side (as opposed to supply-side) solutions like carbon pricing, energy retrofits, and electrification (Erickson et al., 2018; Kemp & Van Lente, 2011; Piggot et al., 2018). Both demand and supply points of intervention are critical for meaningful climate action, attested by what Green and Denniss (2018) articulate as 'cutting with both arms of the scissors.' There may, however, be a case for greater effectiveness of supply-side interventions (Erickson et al., 2018), as nearly two-thirds of global carbon emissions can be traced to just 90 major carbon producers (Ekwurzel et al., 2017). Supply-side constraints can come in the form of economic instruments like production taxes or revoked subsidies, regulatory approaches like prohibitions or quotas, or through government provisions that restrict public financing or compensate, leaving reserves underground (Lazarus & van Asselt, 2018). Supply-side interventions in the fossil fuel industry may thus be highly impactful in mitigating carbon emissions and climate instability.

Supply-side interventions may emerge from both state and non-state actors. One frequently overlooked actor in climate discourse are capital markets (Köhler et al., 2019). Much like the supply-side policy solutions above, access to capital markets plays a key role in sustaining or restricting economic activities that coordinate or stall transformative processes. Through divestment and engagement, capital markets can deter investments in new and existing fossil fuel production, limit carbon lock-in, and reduce stranded asset risk. Thus, capital markets can play a central role in enabling or hindering sustainability transitions.

Capital Market Interventions

Capital markets continue to prop the industry through loans and investments. Since the Paris Agreement in 2015, which established that private markets must mobilize trillions in climate solutions, the world's largest banks have funnelled over four trillion in fossil fuel financing to oil, gas, and coal companies globally (Hanfi Brogger & Marsh, 2021). Many of the world's largest asset managers and pension funds similarly continue to invest heavily in the industry. Blackrock and Vanguard, two of the world's largest asset managers, have over $191 billion and $462 billion in fossil fuels investments, respectively (Fossil Free Funds, n.d.). Just 14 pension funds in the United States have over $81 billion invested in fossil fuels (Stand.earth, 2021). Through their loans and investments, capital markets continue to bolster fossil fuel production, driving up carbon emissions and contributing to climate instability.

However, the emergence of climate-related financial risks, the underperformance of the industry, and increasing climate commitments are forcing investors to rethink their contributions to the fossil fuel industry. Climate-related financial risks, such as the physical costs of climate hazards, the disorderly transition to a low-carbon economy, or liability losses from the effects of climate change (Carney, 2015; D'Orazio & Popoyan, 2019), may threaten the stability of the financial system with systemic effects across the economy (Battiston et al., 2017; Dietz et al., 2016; Monasterolo et al., 2017). Simultaneously, the fossil fuel sector is among the worst performing relative to other industries. Research by Hunt and Weber (2018) and Trinks et al., (2018) finds that the exclusion of fossil fuel stocks results in higher risk-adjusted returns than conventional investments. Consequently, in recognition of the risks of climate change and the responsibilities of capital markets, the industry has begun committing to aligning its investments with climate targets by either divesting from the industry or through coordinated advocacy and shareholder engagement.

Divestment versus Engagement

What started as a form of ethically driven shareholder activism (Guay et al., 2004), the fossil fuel divestment movement has gained considerable momentum since its inception in 2012. It is now the largest divestment campaign in history, eclipsing the prolific Anti-Apartheid divestment campaign that preceded it (Hunt et al., 2017). As of 2022, over 1,500 institutions accounting for a total of 40 trillion dollars in assets under management have committed to divest from the industry (Stand.Earth, 2022). Though gaining prominence as an ethically motivated social movement, there is now an equally compelling financial case for divestment, enhancing the credibility of the movement and motivating prominent investors to distance themselves from the industry (Dordi & Weber, 2019a; Strauch et al., 2020).

Divesting from and limiting future investments in unsustainable industries such as fossil fuels can play a role in restricting unsustainable economic activities (Naidoo, 2020); however, the technical and societal challenges of a sustainable transition (Horne, 2013) alongside policy uncertainty and short-termism (Hafner et al., 2020) have resulted in continued investments in fossil fuels. Consequently, many of the largest and most influential financial institutions maintain a position against divestment, posing that investors could have more influence on the governance of polluting firms through shareholder engagement. There is undoubtedly a clear case in favour of engagement; through the lens of agency theory, equity owners can influence the corporate governance and economic activities of fossil fuel firms in a manner that aligns with climate targets. Given the expanse of incumbent investments in the fossil fuel industry, a low-carbon transition will struggle to materialize without active engagement from key financial actors (Naidoo, 2020). Voluntary coalition groups like the Net-Zero Banking Alliance, the Glasgow Financial Alliance for Net Zero,

and the Climate Action 100+ highlight the channels through which investors could positively influence corporate governance in the fossil fuel industry.

The relationship between divestment and engagement can be either complementary or diametric. On the one hand, investors who support engagement actions argue that divestment will have little impact on the governance of fossil fuel firms. Others argue that divestment could lead to lower returns if funds are reinvested in clean alternatives (Berk & van Binsbergen, 2021). Conversely, divestment proponents cite moral responsibility and potential losses as arguments against maintaining fossil fuel investments. However, these two approaches could also work in tandem, as engagement is backed by an implicit or explicit threat of divestment (Gifford, 2010).

Both approaches remain relatively nascent in the literature, and there is no singular review that attempts to bridge these siloed fields. We thus conduct a bibliometric analysis to examine how these fields compare and identify future avenues of research.

Overarchingly, our research question is, ***how does existing literature on fossil fuel divestment and shareholder engagement discuss the role of investor responsibilities on climate action?*** We answer this question over five steps. First, we ask, what is the research progress to date on divestment and engagement? Specifically, we examine which authors, journals, and institutions most influenced the research on each respective topic. Second, what are the most influential publications on the topic? This may be used as a basis for emerging researchers to familiarize themselves with each field. Third, how do the fields compare? We examine this aspect through a novel interdisciplinary mapping exercise. Fourth, what theories are most commonly applied to engagement and divestment literature? Finally, how are climate change and fossil fuel production discussed in shareholder engagement literature. This will identify gaps for future research agendas.

3.3 Data and Method

This research adopts a mixed approach to answering the research questions, combining bibliometric meta-analysis with inductive and comparative content analyses. By adopting novel advancements in computing and research mapping, a new research agenda on investment strategies for climate action emerge.

Method

Bibliometrics has a deeply established history (Pritchard, 1969) as a process by which to objectively analyze a body of literature. Research adopting the bibliometric methodology has undergone rapid uptake in recent years, with over 55 percent of all bibliometric studies published since 2015. Advancements in computing capabilities and the development of software tools (Aria & Cuccurullo, 2017; McLevey & McIlroy-Young, 2017; van Eck & Waltman, 2010) have facilitated faster more comprehensive analyses on increasingly larger datasets. This analysis is conducted using the open-source R software and several notable packages including Bibliometrix (Aria & Cuccurullo, 2017), Tidytext (Silge & Robinson, 2016), and ggplot2 (Wickham, 2009).

In contrast to a traditional systematic review, bibliometrics describe the structure of scientific literature (Nakagawa et al., 2019), using quantitative analysis to study publication patterns based on the article's metadata. Metadata analysis can be descriptive, such as how many articles have been published, or who are the top authors, journals, institutions, and keywords. Alternatively, it can be evaluative, examining how select authors, articles, journals, or institutions have influenced

subsequent research by others. Bibliometrics are thus better suited to document and visualize the evolution of a field of study and consequently, the trends and opportunities for future research.

We turn next to an inductive content analysis, to examine how the two fields compare. Examining the content of abstracts, we identify common language adopted by scholars in each field and provide insights into prominent themes and concepts within each subsample (Silge & Robinson, 2016). For greater nuance, however, we adopt a novel new method, an interdisciplinary research mapping technique developed by Mutz et al. (2015) and Marrone and Linnenluecke (2020). This method highlights key areas of overlap and disparate themes, which can inform researchers of commonalities, lingering knowledge gaps, and opportunities for future synthesis may lie.

Data

In identifying our final sample, we apply the 'Preferred Reporting Items for Systematic Reviews and Meta-Analyses' (PRISMA) (Moher et al., 2009). Bibliometric metadata was retrieved from the Web of Science database and Scopus via a systematic search of academic literature relating to fossil fuel divestment and shareholder engagement. The associated queries (as presented in Table 3-1) resulted in 1,967 publications.

While fossil fuel divestment is a well-defined field of research, shareholder engagement for climate action or in relation to the fossil fuel industry remains nebulous in academic research. More, shareholder engagement research that explicitly references climate change or the fossil fuel industry is scant. Consequently, to capture the expanse of shareholder engagement literature, we do not narrow our search terms to articles that explicitly reference climate or fossil fuels in the

initial sample selection. However, we subsequently filter such publications for greater extrapolation in section 3.4.4.

Following the initial query, three screening measures were applied to identify relevant articles; the document type was restricted to articles, the language was restricted to English, and the timeline was restricted to articles published before 2021. Thus, a total of 1,459 articles were exported from Web of Science and Scopus. Once uploaded to R, duplicates between the Web of Science and Scopus were removed, based on a common DOI, Title, and publication year. This resulted in a final sample of 137 publications on divestment and 933 publications engagement. Metadata, including authorship, journal, keywords, and abstract, were exported as a BibTeX file in June 2022.

Table 3-1 Sample Selection for Analysis on Divestment and Engagement

	Divestment		**Engagement**		
Query	title+abstract+keywords ("fossil fuel*" AND "divest*")		title+abstract+keywords ("shareholder engag*" OR "investor engag*" OR "shareholder activis*" OR "investor activis*")		
Database	WOS	Scopus	WOS	Scopus	Total
Initial Query	152	151	819	845	1,967
Filter by date, document type, and language	109	89	697	564	1,459
Exclude duplicates and incomplete metadata	137		933		1,070

This table presents a flowchart of the data collection process, including the initial query, screening, and data processing.

Limitations

This is a content analysis of metadata and keywords and consequently, it is not a systematic review of the literature. This offers several advantages, in that it can effectively examine large swaths of data with little bias. The aim is thus not to provide an in-depth review but to provide insight into

the breadth of themes receiving attention. Second, on data collection, the study is limited to the search criteria used in the methodology. For example, literature on Anti-Apartheid divestment campaigns or non-academic reports may not be captured. Similarly, related terms like carbon neutrality or responsible investing are also out of scope of this study.

3.4 Results

We begin with a summary of the current state of research on divestment and engagement through a review of corpus metadata. We consider, for example, the research progress over time, based on the number of publications and total citations over time, top countries and institutions involved in this body of research, influential authors and prominent journals, and top publications in the field. The purpose of this is to visualize the cognitive landscape of a scientific field. It can, for example, provide insight to early career researchers about the international position of key actors and provide a one-stop shop for a systematic review of the most prominent publications in the field.

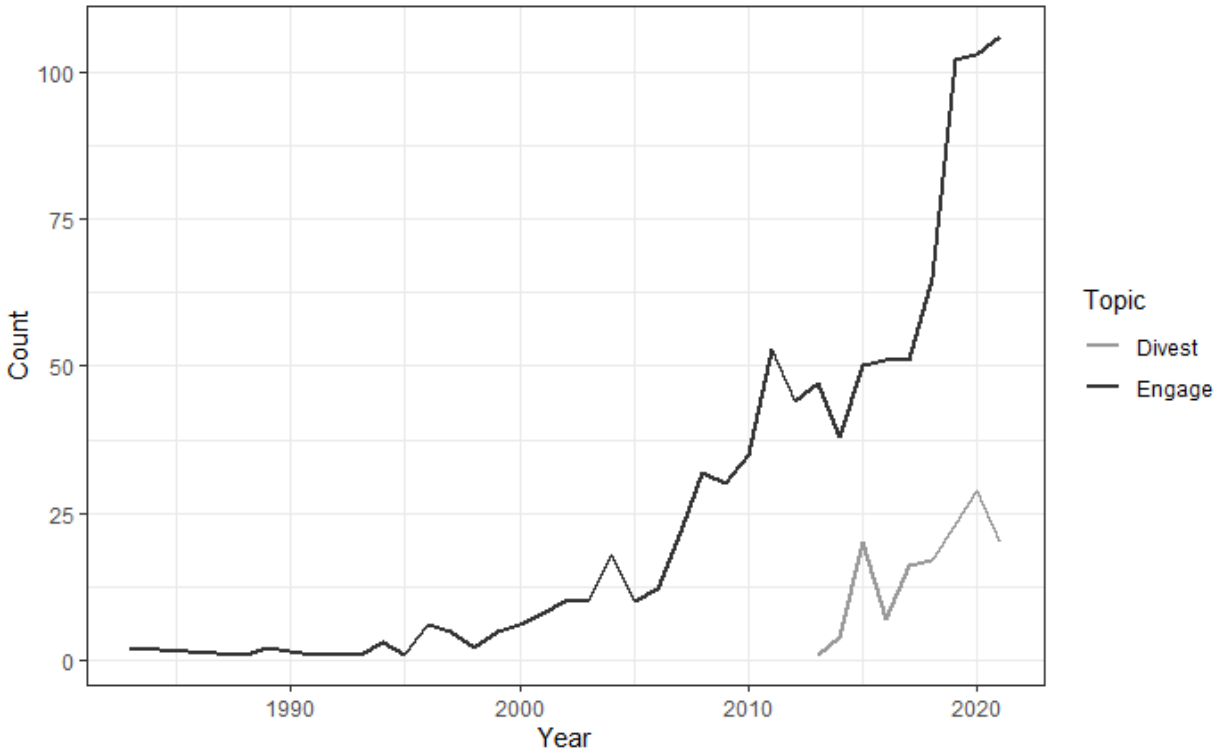
Following the quantitative metadata analysis, we delve deeper into a qualitative analysis of key publications. Here, we gain a deeper appreciation for the nuances of discourse by examining the theoretical frames adopted by divestment and engagement scholars and the state of knowledge on the role of engagement as a tool to enable a managed decline of the fossil fuel industry. The results have foresight potential for future research agendas.

Research Progress

As of December 2021, there were a total of 137 publications on fossil fuel divestment and 933 publications on shareholder engagement indexed to the Web of Science and Scopus. While the

study of shareholder engagement has a lengthier history dating as far back as the 1980s, literature on fossil fuel divestment emerged more recently, gaining prominence in research and practice following the 'Do the Math' campaign from 2012. Figure 3-1 indicates that both fields of study have gained greater prominence in the last decade, with a year-over-year growth of 11.1 percent and 6.9 percent in divestment and engagement-related literature, respectively. The rapid uptake in related publications attests to the enormous interest the field has garnered in recent years, amassing 2,033 and 31,445 citations in divestment and engagement literature, respectively.

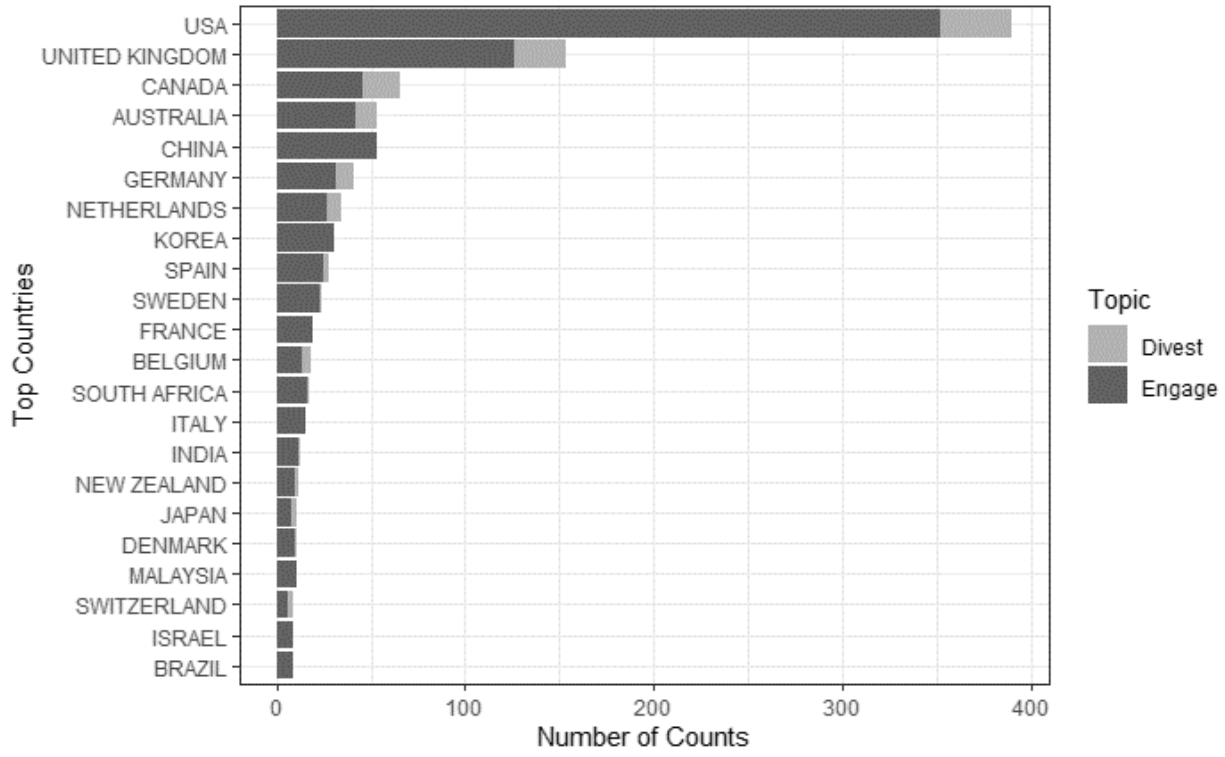
Figure 3-1 Number of publications on Divestment and Engagement



Number of publications on each topic are collated between Web of Science and Scopus and counted by frequency. The number of publications are mapped on the y-axis and years are mapped on the x-axis.

By region, the most prominent publishers in our sample are from the United States and the United Kingdom. Figure 3-2 shows that both countries lead by a substantial margin in the number of publications on divestment and engagement, with 390 and 154 publications, respectively.

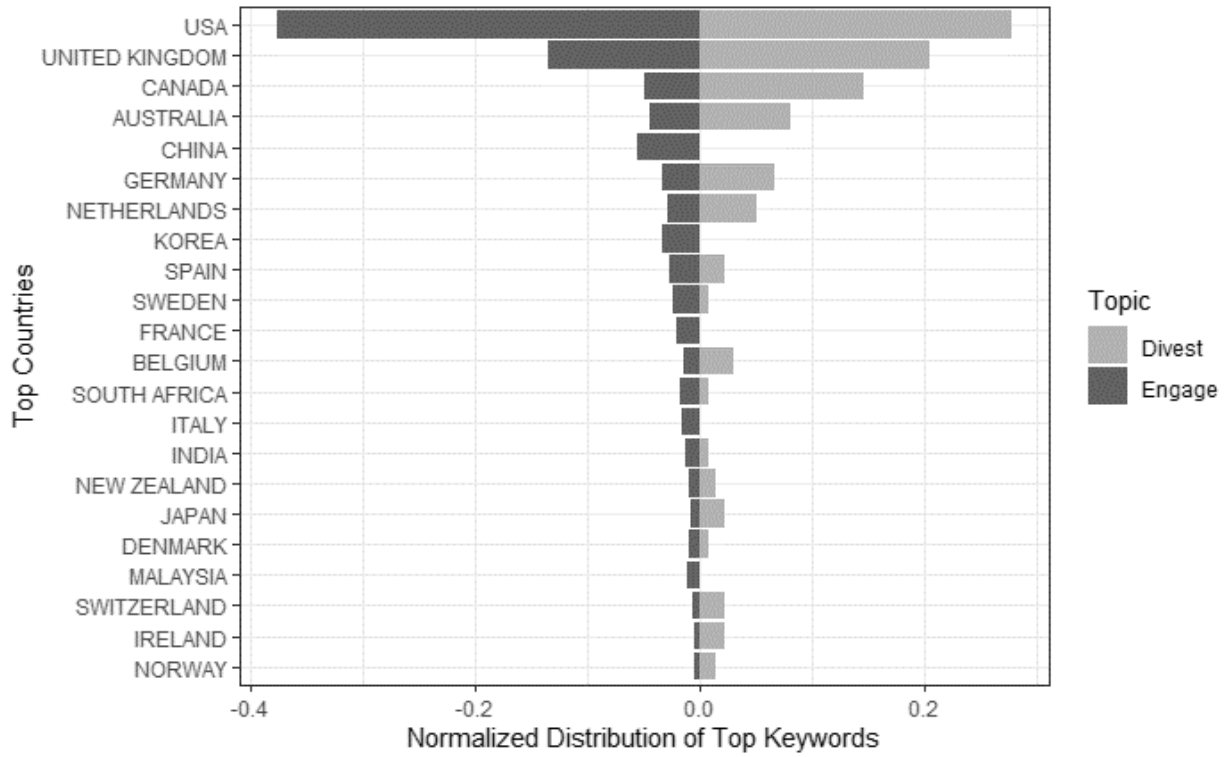
Figure 3-2 Total publications by country, by topic



Countries of authors combined and counted by frequency. The top countries are sorted by frequency and mapped on the y-axis. The frequency by which the keywords appear in each sample is presented on the x-axis.

Proportionally, as presented in Figure 3-3, the United States still publishes most frequently on both divestment and engagement. 37.7 percent of publications on engagement, for example, are published by academics based in the United Sates. Conversely, however, Canada and the United Kingdom publish more frequently on divestment than engagement. Canadian scholars, for example, have published 14.6 percent of literature to date on divestment but just 4.9 percent of literature to date on the engagement. In all, scholars from 18 countries, primarily from the global north, have published on both divestment and engagement.

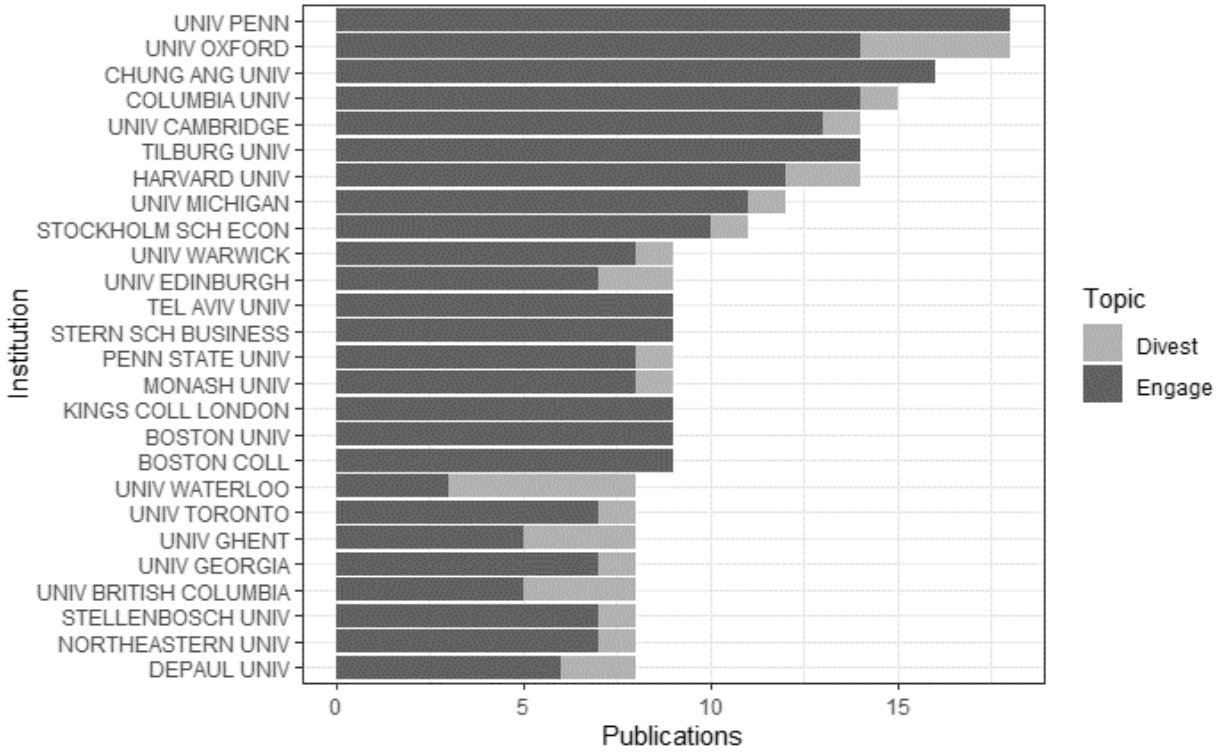
Figure 3-3 Proportion of publications by country, by topic



Author countries are compared between divestment and engagement literature. Top countries are sorted by proportional frequency (the number of instances a country appears divided by total number of papers in the sample) in engagement literature and mapped on the y-axis. The proportional frequency of countries in divestment literature is presented to the right of the center.

Among the top academic institutions in the field, by number of publications, is the University of Pennsylvania in the United States and the University of Oxford in the United Kingdom. Figure 3-4 indicates that several institutions (including the University of Pennsylvania) publish exclusively on shareholder engagement. However, the complementary Table 3-2 indicates that The University of Waterloo in Canada is at the forefront of fossil fuel divestment research, with five publications to date. Notably, there is no prominent institution that publishes exclusively on fossil fuel divestment.

Figure 3-4 Top institutions by number of publications, by topic



Author institutions are compared between divestment and engagement literature. The top countries are sorted by frequency and mapped on the y-axis. The frequency by which the keywords appear in each sample are presented on the x-axis

Table 3-2 Top Institutions by Number of Publications

Divestment		**Engagement**	
University of Waterloo	5	University of Pennsylvania	18
Australian National University	4	Chung Ang University	16
Salem State University	4	Columbia University	14
University of Oxford	4	Tilburg University	14
University of Sussex	4	University of Oxford	14

Turning next to authorship, we find that institutional influence is often led by a few prominent scholars. Of the 1,907 individual authors identified in the sample, 327 scholars (17.1 percent) have published more than one paper in the field, and only 92 scholars (4.8 percent) have published more than two papers in the field. Table 3-3 below presents the top authors in each field. On engagement, Dr. Chune Young Chung at the Chung-Ang University in South Korea is the leading scholar in

our sample, affiliated with a total of 15 publications in the sample. Their research examines the impacts of shareholder activism on corporate governance, ownership, and performance of firms. Dr. Noel Healy is respectively the leading author on fossil fuel divestment, primarily through the lens of energy justice. Other notable scholars include Dr. Olaf Weber from the University of Waterloo, who publishes primarily on the financial case for fossil fuel divestment and Dr. Mathieu Blondeel from the Warwick Business School, who publishes primarily on the social case for fossil fuel divestment

Table 3-3 Top Authors by Topic

Fossil Fuel Divestment		**Shareholder Engagement**	
Healy N	4	Chung CY	15
Blondeel M	3	Liu C	8
Dordi T	3	Viviers S	8
Kmietowicz S	3	Ferri F	7
Stephens JC	3	Mans-Kemp N	7
Weber O	3	Renneboog L	7

Finally, we note that while there are several leading institutions and prolific authors in the fields of divestment and shareholder engagement, the network of co-authorship is largely disconnected. Statistically, authorship networks for both divestment and engagement have low density scores (0.011 and 0.001 respectively), indicating that there are few linkages between established groups of scholars. Consequently, there may be a greater need for collaboration between research clusters.

Last, in our meta-analysis on research progress, we turn to prominent journals in the field. Table 3-4 indicates a similar incongruity between top ranked journals. While engagement literature is primarily found in traditional finance and management journals like corporate governance, journal of business ethics, and the journal of corporate finance, divestment research is more frequently published in social science and policy related journals like Energy Research and Social Science, Energy Policy, and Law and Policy. This incongruity suggests that divestment and engagement

researchers may not be engaging in a common dialogue; we examine this further by identifying the most influential publications in each field below.

Table 3-4 Top Journals by Topic

Fossil Fuel Divestment		**Shareholder Engagement**	
Energy Research and Social Science	8	Corporate Governance	41
Energy Policy	7	Journal of Business Ethics	36
Law and Policy	5	Journal of Corporate Finance	36
Climate Policy	4	Journal of Financial Economics	30
Sustainability	4	Review of Financial Studies	28

In summary, our meta-analysis indicates that while shareholder engagement is a larger field of research than the emerging study of fossil fuel divestment, research on each are often conducted separately with different institutions, scholars, and journals. Notably, the top authors and journals differ substantially, which suggests there is little overlap among researchers that study both phenomena. Thus, it would be of interest for established and emerging scholars to conduct research that bridges the gap between divestment and engagement research.

Influential Publications

Next, to gain a comprehensive understanding of the most influential papers in the field, we examine the top manuscripts by citation count, and the top cited references in the dataset. First, we begin by ranking manuscripts within the sample by citation count (Table 3-5). It is foremost evident that leading divestment literature is often framed through the lens of climate and energy transitions rather than through the lens of finance. The most highly cited paper in our sample, for example, examines divestment as a tool for energy justice (Healy & Barry, 2017). Several instances of highly cited papers are not explicitly about divestment but frame divestment as a critical intervention point for policy and finance to actualize a sustainable transition (Kuzemko et

al., 2020; Otto et al., 2020). It is not until the seventh- and eighth-ranked papers on our list that we begin to see reference to the financial case for fossil fuel divestment (Henriques & Sadorsky, 2018; Trinks et al., 2018).

Conversely, literature on engagement is substantially more focused on performance, with six of the top ten publications referring directly to the role of institutional ownership and activism on corporate social performance, cash holdings, firm performance, and cost of capital. Notably, just one of the top ten studies refers to environmental risk management (Sharfman & Fernando, 2008) - and none of the top publications on engagement reference climate change, carbon, or fossil fuel production, which is particularly insightful given the level of public discourse by investors on positively engaging with polluting industries.

Table 3-5 Top publications on divestment and engagement by times cited

Topic	Study	Citations
Divest	Healy, N., & Barry, J. (2017). Politicizing energy justice and energy system transitions: Fossil fuel divestment and a "just transition". *Energy policy*, *108*, 451-459.	231
Divest	Otto, I. M., Donges, J. F., Cremades, R., Bhowmik, A., Hewitt, R. J., Lucht, W., ... & Schellnhuber, H. J. (2020). Social tipping dynamics for stabilizing Earth's climate by 2050. *Proceedings of the National Academy of Sciences*, *117*(5), 2354-2365.	139
Divest	Kuzemko, C., Bradshaw, M., Bridge, G., Goldthau, A., Jewell, J., Overland, I., ... & Westphal, K. (2020). Covid-19 and the politics of sustainable energy transitions. *Energy Research & Social Science*, *68*, 101685.	100
Divest	Ayling, J., & Gunningham, N. (2017). Non-state governance and climate policy: the fossil fuel divestment movement. *Climate Policy*, *17*(2), 131-149.	99
Divest	Healy, N., Stephens, J. C., & Malin, S. A. (2019). Embodied energy injustices: Unveiling and politicizing the transboundary harms of fossil fuel extractivism and fossil fuel supply chains. *Energy Research & Social Science*, *48*, 219-234.	80
Divest	Green, F. (2018). Anti-fossil fuel norms. *Climatic Change*, *150*(1), 103-116.	66
Divest	Trinks, A., Scholtens, B., Mulder, M., & Dam, L. (2018). Fossil fuel divestment and portfolio performance. *Ecological economics*, *146*, 740-748.	49
Divest	Henriques, I., & Sadorsky, P. (2018). Investor implications of divesting from fossil fuels. *Global Finance Journal*, *38*, 30-44.	38
Divest	Trencher, G., Healy, N., Hasegawa, K., & Asuka, J. (2019). Discursive resistance to phasing out coal-fired electricity: Narratives in Japan's coal regime. *Energy Policy*, *132*, 782-796.	38
Divest	Le Billon, P., & Kristoffersen, B. (2020). Just cuts for fossil fuels? Supply-side carbon constraints and energy transition. *Environment and Planning A: Economy and Space*, *52*(6), 1072-1092.	37
Engage	Johnson, R. A., & Greening, D. W. (1999). The effects of corporate governance and institutional ownership types on corporate social performance. *Academy of management journal*, 42(5), 564-576.	872

Engage	Dittmar, A., & Mahrt-Smith, J. (2007). Corporate governance and the value of cash holdings. *Journal of financial economics*, 83(3), 599-634.	797
Engage	Brickley, J. A., Coles, J. L., & Jarrell, G. (1997). Leadership structure: Separating the CEO and chairman of the board. *Journal of corporate Finance*, *3*(3), 189-220.	737
Engage	Gillan, S. L., & Starks, L. T. (2000). Corporate governance proposals and shareholder activism: The role of institutional investors. *Journal of financial Economics*, *57*(2), 275-305.	650
Engage	Brav, A., Jiang, W., Partnoy, F., & Thomas, R. (2008). Hedge fund activism, corporate governance, and firm performance. *The Journal of Finance*, *63*(4), 1729-1775.	544
Engage	Aggarwal, R., Erel, I., Ferreira, M., & Matos, P. (2011). Does governance travel around the world? Evidence from institutional investors. *Journal of financial economics*, *100*(1), 154-181.	542
Engage	Sharfman, M. P., & Fernando, C. S. (2008). Environmental risk management and the cost of capital. *Strategic management journal*, *29*(6), 569-592.	499
Engage	Cremers, K. M., & Nair, V. B. (2005). Governance mechanisms and equity prices. *the Journal of Finance*, *60*(6), 2859-2894.	489
Engage	Aguilera, R. V., Filatotchev, I., Gospel, H., & Jackson, G. (2008). An organizational approach to comparative corporate governance: Costs, contingencies, and complementarities. *Organization science*, *19*(3), 475-492.	480
Engage	Smith, M. P. (1996). Shareholder activism by institutional investors: Evidence from CalPERS. *The journal of finance*, *51*(1), 227-252.	449

This table presents top cited papers based on how frequently they are cited by articles within the sample. Citations are based on the total times cited as of the Scopus and Web of Science index on the day of sample collection.

More so, examining cited references can give us a sense of the literature well beyond the associated queries. Examining reference lists can, for example, inform readers about seminal literatures and historical contexts through which the field evolved. Table 3-6 presents the top five cited references for each topic. Though there are some overlaps between lists, some seminal papers stand out. 27 of the 137 papers on fossil fuel divestment cite work by McGlade and Ekins (2015) as a seminal reading on carbon budgets. Though this study does not explicitly reference divestment, the concept of the global carbon budget is central to the study of divestment. Relatedly, Ansar et al.'s (2013) research on stranded assets and the fossil fuel divestment campaign is also an influential report; however, it does not appear in our sample as it is not published in a peer-reviewed article. On engagement, in contrast, four of the top five highly cited studies in the sample are captured in our initial query. The overlap between the top publications and top cited references suggests a relatively siloed research focus, whereby researchers seldomly engage with research beyond the confines of the field.

Table 3-6 Top cited references on divestment and engagement by cited references

Topic	Study	Citations
Divest	Ayling, J., & Gunningham, N. (2017). Non-state governance and climate policy: the fossil fuel divestment movement. *Climate Policy*, *17*(2), 131-149.	28
Divest	McGlade, C., & Ekins, P. (2015). The geographical distribution of fossil fuels unused when limiting global warming to 2 C. *Nature*, *517*(7533), 187-190.	27
Divest	Ansar, A., Caldecott, B. L., & Tilbury, J. (2013). Stranded assets and the fossil fuel divestment campaign: what does divestment mean for the valuation of fossil fuel assets?.	26
Divest	Healy, N., & Barry, J. (2017). Politicizing energy justice and energy system transitions: Fossil fuel divestment and a "just transition". *Energy policy*, *108*, 451-459.	20
Divest	Grady-Benson, J., & Sarathy, B. (2016). Fossil fuel divestment in US higher education: student-led organising for climate justice. *Local Environment*, *21*(6), 661-681.	14
Engage	Gillan, S. L., & Starks, L. T. (2000). Corporate governance proposals and shareholder activism: The role of institutional investors. *Journal of financial Economics*, *57*(2), 275-305.	191
Engage	Brav, A., Jiang, W., Partnoy, F., & Thomas, R. (2008). Hedge fund activism, corporate governance, and firm performance. *The Journal of Finance*, *63*(4), 1729-1775.	169
Engage	Smith, M. P. (1996). Shareholder activism by institutional investors: Evidence from CalPERS. *The journal of finance*, *51*(1), 227-252.	157
Engage	Jensen, M. C., & Meckling, W. H. (2019). Theory of the firm: Managerial behavior, agency costs and ownership structure. In *Corporate Governance* (pp. 77-132). Gower.	153
Engage	Gillan, S.L. and Starks, L.T. (2007), The Evolution of Shareholder Activism in the United States. *Journal of Applied Corporate Finance*, 19: 55-73. https://doi.org/10.1111/j.1745-6622.2007.00125.x	148

This table presents the top papers that are cited in our sample. Citations are based on the total number of articles within the sample that reference select study.

We find through this review of highly cited literature that the fields of divestment and engagement appear once again to be substantially different. While divestment is grounded in the science and politics of climate change, engagement continues to be driven by conventional financial motives like performance. It does not appear as though engagement literature has seriously considered its role in the low-carbon transition, raising concerns around its efficacy in practice.

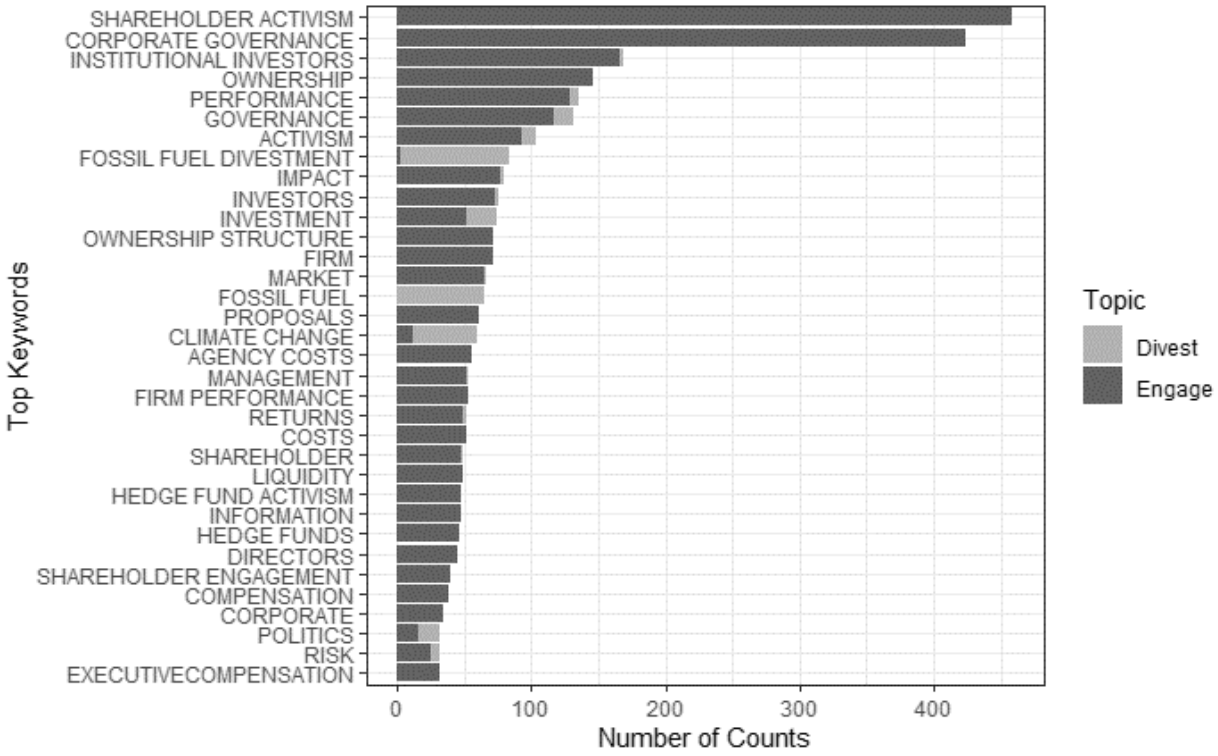
Comparative Analysis of Divestment and Engagement Literature

Turning to the third research question, we examine, more broadly, the key points of discourse in each respective field. Using unstructured data from the abstracts of publications (amounting to a total of 64,218 unique words), we contextualize information about relevant topics and their connections, induce insights to reveal relationships among constructs and theorize on the

emergence and functioning of latent topics on divestment and engagement, which would have otherwise been restricted with strictly quantitative data.

We begin with a simple word frequency analysis based on the content of the author- and journal-identified keywords (Figure 3-5). The two most prominent keywords in our sample are shareholder activism and corporate governance. Both appear exclusively in the engagement subsample. Though corporate governance is not a query in our analysis, it is unsurprisingly a central theme in engagement literature. Conversely, fossil fuels and climate change sparsely appear in engagement literature.

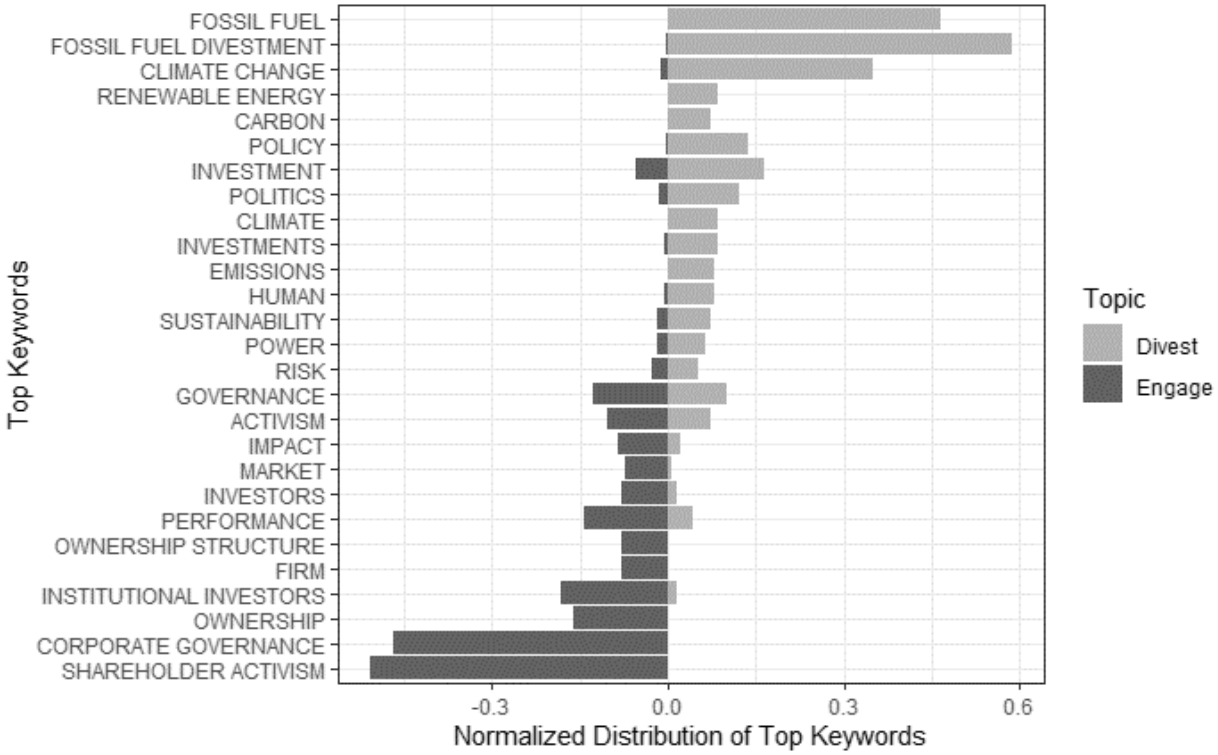
Figure 3-5 Author Keyword Indexed Terms



Author and Scopus associated keywords are combined and counted by frequency. The top keywords are sorted by frequency and mapped on the y-axis. The frequency by which the keywords appear in each sample are presented on the x-axis.

Figure 3-6 below further examines top keywords by how frequently they appear relative to the number of publications in our sample. This provides a normalized frequency for better comparability. Here we see that performance appears in nearly 15 percent of engagement publications but in less than five percent of divestment publications. Conversely, discourse on fossil fuels, climate change, renewable energy, carbon, or policy rarely appears in engagement publications.

Figure 3-6 Author keyword indexed terms by proportion of publications



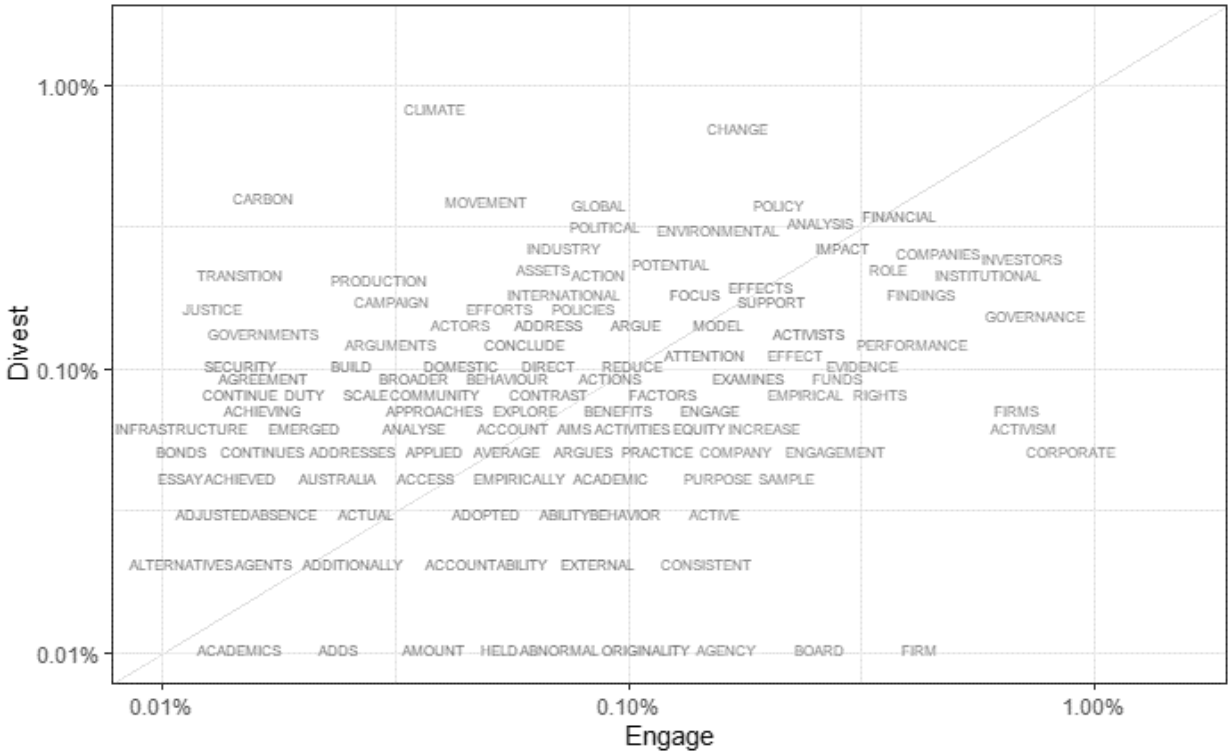
Author and Scopus-associated keywords are combined and counted by frequency. Top keywords are sorted by proportional frequency (the number of instances a keyword appears divided by total number of papers in the sample) in engagement literature and mapped on the y-axis. The proportional frequency of countries in divestment literature is presented to the right of the center.

We turn next to the content of the abstracts using an interdisciplinary research mapping method. First, of the 64,218 words identified between divestment and engagement literature, there is little common ground to be found. A Pearson's product-moment correlation test of engagement and

divestment abstracts found that the two samples are 40.2 percent correlated ($p < 0.001$). That is, the majority of words being used in divestment and engagement literature are different. The results of the map are presented in Figure 3-7 below.

Where engagement diverges is its unique focus on real-world pragmatism. References to carbon, transitions, justice, and governments to the top left of the graph suggest that divestment literature is more conducive to addressing climate action through various channels of influence. Acutely noticeable, however, is a dearth of empirical concepts and themes, which is critical in building legitimacy for divestment among institutional investors. Engagement literature, in contrast, remains considerably focused on governance and empirics, which consequently places less emphasis on the complexities of its real-world applications.

Figure 3-7 Interdisciplinary Research Map



Interdisciplinary research maps are a tool to bridge disciplinary studies based on similar and diverging keywords. Keywords are distributed by proportional frequency (that is, the frequency of the keyword compared to the total number of keywords) over a scatterplot, where the x and y-axes correspond to word frequencies in engagement and

divestment literature, respectively. Words closer to the diagonal line are commonly found in both corpora, while keywords farther away from the diagonal line are unique to one field.

Table 3-7 summarizes the keywords most frequently associated with divestment and engagement literature. Words that are unique to divestment focus primarily on the operationalization of climate action through, for example, politics, social movements, and through the lens of morality or justice. Comparably, shareholder engagement literature prioritizes the firm through the role of management or the investor in providing information or controlling the firm. This suggests once again that engagement literature falls considerably short in boundary-spanning research discussing the environmental dimensions associated with engagement activities.

Table 3-7 Top unique words by topic

Fossil Fuel Divestment		**Shareholder Engagement**	
Carbon	0.96	Corporate	11.70
Climate	0.96	Activism	7.49
Transition	0.94	Firms	5.97
Justice	0.94	Management	4.81
Politics	0.94	Investor	4.64
Moral	093	Consistent	4.38
Governments	0.92	Information	3.98
Supply	0.91	Targeted	3.81
Movements	0.90	Investigate	3.75
Security	0.90	Control	3.61

This table expands on the interdisciplinary research map to presents a list of keywords that are most associated with the fossil fuel divestment corpus (column 1), and the shareholder engagement corpus (column 2). The score is calculated as the difference between the proportional frequency value for each corpus.

Theoretical Frames

In answering research question four, we examine some theories that appear in each sample. The most common among engagement literature is agency theory, stakeholder theory, and institutional theory. Conversely, while divestment literature more frequently references theories of change, social movement and mobility theory, and discourse theory – theoretical contributions appear to be less central to divestment literature.

Agency theory dominates research discourse on shareholder engagement and governance (Goranova et al., 2017; Othman & Borges, 2015) as a means of rationalizing why shareholders pursue activism in response to agency problems (Gillan & Starks, 2000). The agency problem, typically denoted as a principal-agent conflict between shareholders and self-interested managers, has given rise to substantial research on the disconnect between opportunistic behaviours of the firm and the maximization of shareholder value (Eisenhardt, 1989; Fama & Jensen, 1983; Jensen & Meckling, 1976). Consequently, much of the literature on engagement focuses primarily on behaviours that result in firm performance and value maximization (Hadani et al., 2011; Y. K. Kim & Koh, 2020; Zorn et al., 2017). Unsurprisingly, there are no divestment studies within our sample that are based on agency theory.

Conversely, institutional theory assumes that shareholders and firms may be guided more by social legitimacy concerns than by profit maximization (DiMaggio & Powell, 1983; Judge et al., 2010). In the case of the firm, activism may arise in response to management or regulations that wish to pursue politically or socially motivated objectives instead of shareholder value maximization (Bates & Hennessy, 2010; Yamahaki & Frynas, 2016). Alternatively, in the case of the shareholder, institutional theory may explain the differences between financially-driven and socially-driven shareholder activism (Cundill et al., 2018; Johed & Catasús, 2015; Mansell, 2012; Nordén & Strand, 2011). Finally, some scholars attempt to blend institutional and agency theory to explain how managers are influenced both by value maximization and by the values and norms of the institutional environment (Bao & Lewellyn, 2017). On divestment, studies draw on institutional theory to understand how fossil fuel divestment, through normative pressures, may influence financing flows to the oil and gas sector (Cojoianu et al., 2021; Schifeling & Hoffman, 2017).

The third notable theoretical lens by which shareholder engagement and divestment are examined is through the lens of stakeholder theory, which recognizes that managers make decisions inlight of a range of interconnected and disparate interests (Donaldson & Preston, 1995; Freeman, 1984; Mitchell et al., 1997). Disconnects in interests and influence can lead to conflict and, thereby, increased agency costs between shareholders and other stakeholders (Hamilton & Eriksson, 2011; Stathopoulos & Voulgaris, 2016; Yang et al., 2018). The acknowledgement that corporations have direct responsibilities to other non-financial stakeholders has also been foundational in understanding the ethical positions of firms (Goodman & Arenas, 2015; Mansell, 2012), and consequently, this framing is often seen in sustainability and corporate social responsibility-related engagement and divestment literature (Dordi & Weber, 2019b; Fassin, 2012; Gond & Piani, 2012; Guay et al., 2004; Sulkowski et al., 2017).

Divestment literature similarly adopts varied theoretical lenses to explain how the movement might influence firms. Studies that examine the financial impacts of divestment (Henriques & Sadorsky, 2018; Hunt et al., 2017; Trinks et al., 2018) frequently cite modern portfolio theory to explain the relationship between social responsibility and financial performance. Conversely, discourse theory is frequently cited to understand how advocates frame and communicate the divestment narrative to maximize the adoption of the movement (Brown & Sovacool, 2017; Healy & Debski, 2017). To understand the growth of the movement, Maina et al., (Maina et al., 2020) reference mobility theories to examine the spread of divestment campaigns in higher education institutions. Finally, several studies adopt theories of change as a way of examining how divestment may plausibly lead to the desired change in policy or norms, notably the managed decline of the fossil fuel industry (Abrash Walton, 2018; Hestres & Hopke, 2020).

We find, once again, a stark delineation in the theoretical frames used to explain engagement and divestment. Engagement literature continues to rely on traditional isomorphic management theories that are intrinsically tied to the performance of the firm. These theories are particularly poor at explaining how shareholders may engage with the industry in a manner that incites a managed decline. Conversely, divestment theories vary depending on the lens by which the movement is studied.

Engaging on Climate Change

Finally, we examine how engagement literature relates to the issue of climate change. Of the 933 studies on engagement in our sample, a mere 43 studies (4.6 percent) reference climate change, fossil fuels, coal, oil, gas, or carbon.

Most of these references are cursory at best. A sizable share of studies in our sample examines the role of investor engagement in achieving the sustainable development goals (van Zanten et al., 2021) or in improving corporate social responsibility or environmental, social and governance considerations of the firm (Benijts, 2014; G. L. Clark & Hebb, 2016; Dam & Scholtens, 2012; Kölbel et al., 2020; Michelon & Rodrigue, 2015; Robinson et al., 2020; Velte, 2020). While there is evidence that corporate social responsibility-related shareholder activism can target climate change considerations, these works are primarily in relation to the connection between environmental risk and shareholder value (Monks et al., 2004).

Studies that do engage directly with topics of climate change or fossil fuels remain normative in nature, indicating the study is still in its infancy. Typically, this literature focuses on the relation between firms, shareholders, and climate policy. Ghahramani (2020), for example, examines

whether institutional investors have a legal responsibility to adopt environmental intergenerational equity in shareholder activism. Venuti and Wilder (2018) find that such investor demands can enhance legal requirements to demonstrate good governance with respect to addressing climate change, managing risk, and related disclosures. Integrating climate considerations into investment decision-making to manage climate-related risks is not yet encouraged by existing legal frameworks and dominant approaches to investment (Foerster et al., 2021); however, there is evidence that both engagement and regulation can spur changes in organizational practices both at the firm and industry level (C. E. Clark & Crawford, 2011; Reid & Toffel, 2009). Relatedly, studies have begun incorporating transdisciplinary frames around corporate dialogue on climate change as a means to study the effectiveness of engagement and regulation (Cook, 2012; Dahl & Fløttum, 2019; Ferraro & Beunza, 2019; MacLeod & Park, 2011). Finally, there is some evidence that successful engagement activities are more probable in firms with higher reputational concerns and higher capacity to implement changes – and these engagements can result in positive abnormal returns, particularly when shareholders collaborate on successful engagements (Dimson et al., 2015, 2021).

Comparably, few studies explicitly examine the role of shareholder engagement in the fossil fuel industry or carbon emissions. Several studies focus on a firms decision to disclose climate change information through, for example, the carbon disclosure project - finding that shareholder activism appears to be most effective in firms that are least likely to ensure major negative impacts from tightening emissions regulations and that these initiatives can increase shareholder value (Benz et al., 2021; Flammer et al., 2021; E. H. Kim & Lyon, 2011; Wegener et al., 2013). One notable study by Azar et al., (2021) find that prominent shareholders have substantial influence in reducing corporate carbon emissions in large firms with high carbon emissions, in which they hold a

significant stake. Several papers call for greater research on the role of engagement in climate action. Velte and Obermann (2021) call for greater future research on the impact of institutional investors on proxy voting in line with climate change policy, indicating this continues to be a gap in engagement research. Relatedly, Louche et al., (2019) call for greater quantitative research on the impact of engagement activities on a firm's ability to transition to a low carbon economy.

Notably, there are several glaring gaps in the engagement literature to date. First, there is no evidence that engagement in the fossil fuel industry has positively influenced the governance of said firms (for example, by aligning business strategies with net-zero commitments) or that engagement has resulted in lower emissions. Morse so, there is little research to indicate who exactly can influence the fossil fuel industry through engagement activities. Finally, there is no research that frames the complementary relation between engagement and divestment; engagement can only be truly effective when matched with the threat of divestment.

3.5 Discussion

This study finds that research on the role of engagement and divestment for climate action are substantially more distinct and disparate than previously thought. Both approaches remain relatively nascent and siloed in the literature, and this is the first review of its kind to compare the two fields.

First, we find that authors, journals, and institutions vary between divestment and engagement literature. We also find that there is little collaboration between research groups, indicating that scholars often work detached from each other. Relatedly, we find that engagement scholars publish primarily in management journals such as Corporate Governance, the Journal of Business Ethics,

or the Journal of Corporate Finance, whereas divestment scholars publish more frequently in environment and policy journals. This disconnect is even more striking when looking at top publications in each field. The results do not come as a surprise given the focus of each field, identified by top keywords and abstracts. While divestment research examines varied points of focus, from financial performance to environmental justice, engagement literature is primarily focused on corporate governance and financial performance.

Our examination concludes by identifying key theories and a closer examination of engagement in the context of climate change and fossil fuels. The results indicate that engagement is often framed in conventional management theories like agency theory, institutional theory, and stakeholder theory, while divestment literature engages with more transdisciplinary schools of thought, such as the theory of change and theories of mobilization and discourse.

On future research, our results indicate that literature on shareholder engagement in the fossil fuel industry or in response to climate change is severely lacking. Financial performance continues to be a foundational principle in engagement literature, and there is no study that examines the role of engagement in evoking a managed decline of the fossil fuel industry. Given the prominence of engagement theories on maximizing shareholder value, it is unsurprising that there is little research in this space. There is, however, a case for more transdisciplinary theoretical framings on how engagement can enable a low carbon transition. Finally, there is no research on engagement that identifies who the most influential shareholders are or the tools by which they can align fossil fuel firms' operations with a low-carbon transition. Thus, our review asserts that if shareholders make the claim that engagement can address the climate crisis, there is little academic backing for this.

4. A VOICE FOR CHANGE? A NETWORK ANALYSIS OF OWNERSHIP AND CONTROL IN CANADA'S FOSSIL FUEL INDUSTRY

4.1 Introduction

The purpose of this paper is to examine how key financial actors can influence the economic activities of fossil fuel corporations and, consequently, how those activities may bolster or undermine climate change efforts. We understand that to mitigate the worst effects of climate change, increased concentrations of greenhouse gas emissions most affiliated with fossil fuel combustion must be curtailed. Seminal research on the global carbon budget calculates that to limit global temperature rise to under 2°C, the majority of economically proven fossil-fuel reserves cannot be developed (M. R. Allen et al., 2009; Meinshausen et al., 2009). Given the urgency to restrict carbon emissions and mitigate the worst effects of global warming, climate scientists now call for a ceiling limit on emissions - a "carbon-constrained" future driven by a socially (as opposed to physically) imposed limit to carbon production (Jaccard et al., 2018).

Financial actors play a key role in whether fossil fuel corporations can continue business as usual, as their investments directly influence the industry's ability to continue extractive activities. Shareholders with sizable equity ownership in fossil fuel corporations (those with greater than five percent ownership are referred to as blockholders) take an active interest in monitoring the governance of the firms they invest in given their entrenched incentives for them to succeed; and have a considerable collective influence on the corporate governance of these firms (Fichtner et al., 2017). Environmental and climate change activists have long recognized the influence of financial actors in supporting (and curtailing) environmentally destructive activities. This has since driven the largest divestment campaign, against the fossil fuel industry, to date (Hunt et al., 2017).

However, understanding whether investors may be incentivized to influence economic activities associated with climate instability has largely been ignored in academia (Galaz et al., 2018).

This research contributes to the literature on equity ownership, corporate governance, and the climate crisis by conducting a network and sensitivity analysis of the 'Big Five' Canadian fossil fuel corporations. The study combines methods by Carroll & Huijzer (2018) and Galaz et al., (2018), to first identify who the major shareholders are and second, how sensitive the industry is to shareholder influence. Additionally, a novel scoring tool is introduced, that combines ownership weights, sensitivity measures, and emissions data to rank shareholders by their potential influence. In doing so, this paper identifies key financial actors in Canada's fossil fuel industry and quantifies how sensitive the industry is to external financing. The study contributes both theoretically and practically to understanding how key financial actors can influence the economic activities of fossil fuel corporations and consequently, how those activities may bolster or undermine climate change efforts.

This paper is organized as follows. Section two provides an in-depth look at the power dynamics of Canada's fossil fuel industry and the financial sector, as well as a theoretical framing that links financial actors to corporate governance. Section three presents the data and methodology. Section four highlights the empirical results. Finally, section five concludes the analysis with discussion.

4.2 Literature

This study is motivated by three factors. To mitigate the worst effects of climate change, fossil fuel production must be curtailed. The decision to curtail production will depend on the governance of fossil fuel firms, which in turn are influenced by major shareholders. Activists have called upon

major shareholders to play a more active role in influencing the corporate governance of fossil fuel corporations as research suggests that blockholders can influence corporate strategy. However, there is currently no research that examines to what extent major shareholders can influence the governance of Canada's fossil fuel corporations. This research is timely and relevant for both theory and practice, in understanding the relationship between major shareholders, corporate governance, climate stability, and in bridging the gap between financial and climate research.

Fossil Fuel Production and the Climate Crisis

Over the last century, fossil fuel production gained dominance as the primary source of energy, resulting in labour-saving, comfort-providing, and energy-efficient technologies that revolutionized the quality of life for much of the developed world (Smil, 2000). Access to energy, primarily from fossil fuel production has since become a precursor to prosperity, entrenched in the very fabric of our economic capacity and culture (Princen, 2015). With this influence over prosperity came immense power and control—control that is highly concentrated among few nationally- and privately-owned corporations (Alexeyev et al., 2015; Campanale & Leggett, 2011; Carroll & Huijzer, 2018; Heede, 2014).

However, increased concentrations of the greenhouse gases most affiliated with fossil fuel use (Hansen et al., 2008; Quéré et al., 2013) continue to accumulate well beyond the safe operating space, raising global temperatures by half of the globally accepted 2°C target agreed upon at the Copenhagen Accord (Accord, 2009; IPCC, 2014).

There is thus an increasing need for carbon constraints to mitigate the consequences of climate change (Lazarus & van Asselt, 2018). Our rapidly dwindling global carbon budget (M. R. Allen

et al., 2009; Meinshausen et al., 2009) has shifted the climate discourse, which has historically operated within a paradigm of incremental emissions reductions from demand-side end-uses (Steffen et al., 2018), to a more urgent paradigm oriented toward rapidly eliminating emissions by restricting the supply of fossil fuels (Lazarus & van Asselt, 2018; Strauch et al., 2020). The fossil fuel industry is among the most polluting industries, 63 percent of global industrial emissions can be directly traced to 90 "carbon majors," 50 of which are public investor-owned companies (Heede, 2014). This has put the responsibility of decarbonization primarily on curtailing fossil fuel production within a handful of corporations.

Corporate Influence on Climate Change Policy and Governance

Curtailing fossil fuel production in line with global carbon budgets may, however, face formidable political constraints (Jenkins, 2014). The theory of economic regulation (Stigler, 1971) asserts that industries with political power, like the fossil fuel industry' will influence regulators to design policy in their favour, Supply-side constraints to fossil fuel production impose the costs of pollution on small group of politically influential emitters, which makes such policies susceptible to regulatory capture (Tvinnereim & Mehling, 2018). Through lobbying efforts, such polluting industries may suppress effective climate policy, if these policies are perceived to be of material risk to the industry (Olson, 1965, 1984). Thus, fossil fuel majors are unlikely to restrict emissions alone, rather will likely work to subdue effective climate policies. We argue then, that the impetus for change could come from stakeholder pressure.

Stakeholder theorists (Freeman, 1984) would argue that any group or individual can influence the governance of an organization. Governments, non-governmental organizations, investors, and customers alike can pressure firms to reduce their emissions (Cadez et al., 2019; Kolk & Pinkse,

2007; Sprengel & Busch, 2011), however, the potential impact of the stakeholder is dependent on the claim, or salience, of the stakeholder on the company (Mitchell et al., 1997; Rowley, 1997). Through the lens of resource dependence theory, organizations will give greater salience to external actors, like financiers, who control critical resources required for corporate functioning (Pfeffer, J.; Salancik, 1978). Shareholders may thus meaningfully influence corporate governance if they are salient to the firm and if it is perceived to be in their interest.

Financial Risks of Fossil Fuel Investments

Significant financial commitments continue to flow to the fossil fuel industry, even as it faces the financial risks associated with a dwindling carbon budget (Mercure et al., 2018; Supran & Oreskes, 2017). These financial commitments are often tied to a small and tightly-knit core of financial institutions (Vitali et al., 2011), which can collectively exert influence on corporate governance strategy (Fichtner et al., 2017).

Institutions and investors have long recognized their influence on society and the environment (Bansal & Song, 2017). However, the recent interest in incorporating non-financial (environmental, social, and governance) indicators into investment decisions are driven by risk management rather than moral arguments (O. Weber & Feltmate, 2016). If existing reserves remain grounded, the valuation of fossil fuels companies may suffer unanticipated or premature write-downs (Caldecott et al., 2014). These potentially "stranded assets" are conservatively valued at over 28 trillion USD and are most concentrated in high-cost and high-carbon sources of production like Canada (M. C. Lewis et al., 2014). There is increasing evidence indicating that continued investment in fossil fuel industries is not only contradictory to global carbon reduction targets but is also a failing investment strategy (Arbuthnott & Dolter, 2013; Dordi & Weber,

2019b; Henriques & Sadorsky, 2018; Hunt & Weber, 2018; Trinks et al., 2018). Given the confluence of production costs, clean energy sector progress, and the emergence of climate change as a major political issue, global energy systems may be approaching a tipping point (Jaccard et al., 2018). Thus, there is a clear financial case to intervene in the fossil fuel industry to mitigate the financial risks associated with climate change.

Many shareholders, whether driven by a moral or financial cause, have divested their fossil fuel holdings (Dordi & Weber, 2019a). As of 2020, over 1,200 institutional investors from faith-based organizations, philanthropic foundations, educational institutions, pension funds, and governments have divested over 14 trillion USD from the industry (gofossilfree.org, 2021). Activists have called upon major shareholders to also divest from the fossil fuel industry, however, many investors maintain their investments in favour of engagement. Critics of divestment argue that only shareholders can put pressure on firms in their annual meeting and therefore, divestment weakens the influence of ethically concerned shareholders (Sprengel & Busch, 2011). Moreover, the divested equity will simply be acquired by less scrupulous investors relatively quickly and at a discounted rate (Ansar et al., 2013). The Canada Pension Plan and Investment Board (CPPIB) for example, has long stood behind its mandate to engage with rather than divesting from the fossil fuel industry (J. K. Rowe et al., 2019), citing that the pension fund can more effectively press for positive change as an engaged investor and that dropping a major sector from its portfolio would not be financially prudent.

Engaging with the Fossil Fuel Industry

For shareholders that choose to maintain investments with fossil fuel firms, there is an impetus that they meaningfully engage in a manner that pressures firms to align with climate targets and

mitigates the climate-related financial-risk of inaction. We blend two theoretical approaches in this study, from management and from political economy, to explicate why shareholders may choose to engage with the industry.

Agency theory first presents a framework by which we understand how major shareholders can influence the governance of corporations through active engagement; it answers, why major shareholders may be motivated to affect climate stability through intervention in fossil fuel firms (Daily et al., 2003; Fama & Jensen, 1983; Jensen & Meckling, 1976). The growth of equity-based institutional investments and large blockholders (shareholders with greater than 5 percent of a firm's outstanding shares) by the 1970s, gave shareholders much greater collective power to influence the productive yields and market values of the corporate stocks they held (Lazonick & O'Sullivan, 2000; Morck et al., 1988). Many firms now exhibit ownership structures with at least one or a few blockholders (Bajo et al., 2020) who collectively exert governance through three mechanisms – exit, voice, and loyalty (Hirschman, 1970). Namely, shareholders show loyalty by holding shares, express discontent through voicing their positions through direct (or the threat of) shareholder-sponsored proposals and shareholder voting, or exit through selling their shares (Gordon & Pound, 1993). The proportion of equity ownership held determines the shareholder's influence on the strategic decisions of the firm (Appel et al., 2016; Dimson et al., 2015).

However, the question remains, will these shareholders use their influence to restrict emissions? Traditionally, agency theory would posit that shareholders would only exert influence on a corporation to increase shareholder returns - not decrease its productive capacity. More, evidence on proxy voting by shareholders indicates that many prominent investors continue to vote against climate-related shareholder resolutions (Martin et al., 2020), indicating that investors may in fact, not be meaningfully engaging with the fossil fuel industry.

The capital as power theory (Nitzan & Bichler, 2009), might provide context to why shareholder engagement with the fossil fuel industry might be misaligned. Under this framing, financial capital is a matter of an owner's ability to exert material and ideological power over a firms governance (Bichler & Nitzan, 2021). The ownership of shares within this framework is a forward-looking indicator of future profit, namely that these investors anticipate the firm continues to grow to meet its future earnings targets (Baines & Hager, 2019). The theory consequently asserts that shareholders might be motivated to maintain favourable market conditions as a means to mitigate against the financial risks of stranded assets. Under this perspective, a few large shareholders stand to gain substantially through monetizing the destruction of the world's climate (Muzio, 2016) and will continue to engage with the industry in a manner that contradicts effective climate solutions. However, capital can also be used to re-shape society if the power is regulated accordingly by financial supervisors. Climate-related policy interventions might, for example, be able to direct capital toward a more sustainable direction that helps to both restrict economic activities that contribute to climate instability while also mitigating financial risks.

Consequently, we postulate that major shareholders can affect climate stability through intervention in fossil fuel firms (Galaz et al., 2018). However, the determinants of intervention depend on how sensitive the industry is to concentrated ownership (Edmans, 2014; Holderness, 2005). In contrast to intervention, shareholders may choose to sell their shares if the firm's strategy diverges from the positions of its shareholders (McCahery et al., 2016). However, blockholders may not be able to easily divest from firms that do not meet their expectations without triggering a precipitous decline in the value of their holdings (Daily et al., 2003). Given the salience of shareholder influence on corporate governance, these theories explain how blockholders influence corporate governance.

This research thus contributes to a growing study of equity ownership dynamics (Bajo et al., 2020; Carroll & Huijzer, 2018; Dimson et al., 2021) to understand whether shareholders can and will influence the economic activities of firms that contribute to climate instability. It complements similar works on equity ownership in the fossil fuel industry (Carroll & Huijzer, 2018) through a comparative analysis of ownership dynamics, and expands on existing research by examining how much influence a shareholder might yield over the governance of these firms.

4.3 Data and Method

We adopt a network and sensitivity analysis to uncover the structures of ownership in the 'Big Five' fossil fuel companies in Canada. The analysis is divided into three parts; a network analysis of the industry, a sensitivity analysis of the firms, and a ranking of the most prominent and influential actors.

Data

The five fossil fuel firms examined in this study (referred to as the "Big Five") are Suncor Energy, Canadian Natural Resources Limited (CNRL), Cenovus Energy, Imperial Oil, and Husky Energy. This sample holds significant control of the oil sands industry, accounting for 79.3 percent of Canada's bitumen productive capacity (Hussey et al., 2018). The current sample of the Big Five is also appropriate given the concentration of entities responsible for most of the carbon emissions globally (Heede, 2014). Canadian fossil fuel firms are of particular interest, given that Canada is a resource extractive nation and that the oil sands are among the most expensive to produce. Moreover, the industry has undergone a period of consolidation, resulting in many of the smaller

firms being acquired by the Big Five. In fact, since collection of this data, Husky Energy has amalgamated with Cenovus Energy. Finally, these corporations are important to the Canadian oil sands, due to their oligarchic capacity to structure the economic dynamics of the entire oil sands industry. Thus, the Big Five captures not only concentration in productive capacity, but the concentration of shareholder ownership and influence relative to carbon emissions and climate impacts.

Ownership data of the Big Five companies is collected from the *Orbis* database, which provides a list of owners by the percentage of shares outstanding which they own. Ownership data is collected over annually, spanning a ten-year period from January 2009 to December 2018. Only holdings with at least 0.01 percent share in the company are included in the *Orbis* database, and thus, small shareholders are excluded from this analysis. We note one methodological amendment, whereby similarly named subsidiaries may appear to own several holdings in a company, that collectively amount to greater than 100 percent ownership. This is a noted artifact of the data collection process from the *Orbis* database, which must be manually account for. In the few instances where a shareholder is reported in *Orbis* to have multiple holdings in a company (through different subsidiaries or because of diverging sources of data), we select the greater proportional ownership and exclude the rest. In 2018 for example, Husky's major shareholders included Hutchison Whampoa Luxembourg Holdings Sarl (40.19 percent), CK Hutchison Holdings Limited (40 percent), and Hutchison Whampoa Limited (34 percent). Thus, only one 'Hutchison Whampoa' (40.19 percent) is included in the study.

Analysis

Our analysis begins with a bipartite (two-mode) network of institutional investors (Bajo et al., 2020; Carroll & Huijzer, 2018). Replicating methods from Carroll and Huijzer (2018), the network analysis begins with an exposition of ownership characteristics by region, by type, and over time. A stepwise reduction of ownership by region and type is also conducted, to compare small and large shareholders. Our networks, modelled at the one percent and five percent intervals maps the directed link between two sets of actors, from the blockholders to the fossil fuel corporations. We examine degree and closeness centrality measures to measure the density and distance of the networks of ownership. Finally, we present a brief qualitative analysis of major blockholders and their positions on fossil fuel engagement. Changes in share ownership by region and type, the stepwise reduction of shareholder ownership, and network structures are compared and contrasted with Carroll & Huijzer's (2018) findings.

We next replicate the methodology by Galaz et al., (2018), which evaluates the degree of collective influence of prevalent financial actors to directly affect climate stability through centralized stewardship and governance. Beyond simply identifying major shareholders, it is equally important to examine how sensitive the industry is to concentrated ownership, through collective block holding power (Edmans, 2014; Holderness, 2005). Sensitivity to concentrated ownership is measured using the Herfindahl-Hirschman Index and market debt to capital, as indicators of market concentration and sensitivity to financiers respectively.

Finally, shareholder ownership and sensitivity are combined to present a ranking of the most prominent shareholders, not only by the size of their holdings, but also by the firm's sensitivity and emissions potential. This measure multiplies a shareholders holdings in each of the big five by the firm's debt to capital ratio, Herfindahl-Hirschman Index, and potential gigatons of carbon

emissions collected from the Carbon Underground 200 (Fossil Free Funds, 2020). In line with Galaz et al., (2018) we assert that shareholders with holdings in firms with a higher sensitivity score and higher potential emissions have greater influence in the industry and consequently have greater impetus to shift corporate governance. This analysis is conducted using the open-source R software and several notable packages including igraph (Csardi & Nepusz, 2006) and network (Butts, 2008).

4.4 Results

Descriptive Statistics

We begin with a brief description of the selected firms. Our sample of the Big Five corporations is selected in line with Hussey et al., (2018) as five of the largest bitumen extractive corporations that form the core of sustained power in Canada's fossil fuel industry. Table 4-1a summarizes some key financial metrics of each of these corporations. As of 2018, the big five owned 273 billion CAD in total assets and $153 billion in market capitalization. Suncor and CNRL are among the largest of the five companies, followed closely by Imperial, Husky, and Cenovus.

There is a considerable disparity between the capital expenditures and gross profits of the Big Five, as presented in Table 4-1b. As a measure of organizational and extractive capacity, CNRL and Suncor have the highest proportion of gross profits (at 69.5 percent and 58.9 percent respectively) whereas Imperial has the lowest (at 20.9 percent). Conversely, in relation to the costs associated with extraction and refining, Husky and Imperial have the highest direct costs (at 63.7 percent and 79.1 percent respectively) whereas CNRL has the lowest (at 30.5 percent). Finally, high depreciation and amortization (as in the case with CNRL and Suncor) indicate their ability to replace the current productive capacity required to maintain their strategic role as top producers.

An analysis of variance (ANOVA) identifies that there is significant variation between gross profits and direct costs (P >0.01, Cramer's V = 0.341). Pearson residuals attest that CNRL and Suncor have higher gross profits than direct costs whereas Imperial have higher direct costs than gross profits. The message holds that there is notable variation in operations and productive capacity between the Big Five. Looking at trends over the past decade, revenues, capital expenditures, share prices, and dividends followed a trajectory similar to the commodity cycle of growth, contraction, and consolidation. On average, capital expenditures and revenues in the fossil fuel industry were greatest in 2012 and lowest in 2015 and 2016 respectively. Collectively, these financial metrics indicate how a firm is performing relative to their competitors. The descriptive analysis indicates that the Big Five differ in capacity and have evolved over time. Consequently, shareholder influence will likely also differ between these firms.

Table 4-1 Financial fundamentals and metrics

1a Financial Fundamentals					
Corporation	Cenovus	CNRL	Husky	Imperial	Suncor
Total Assets	35,174	71,559	35,225	41,456	89,579
Market Capitalization	11,795	39,728	14,182	27,163	60,813
Operating Revenue	20,895	21,161	22,843	34,964	38,952
Net Income	-2,669	2,591	1,422	2,314	3,293
Market Price	9.6	32.94	14.11	34.59	38.13

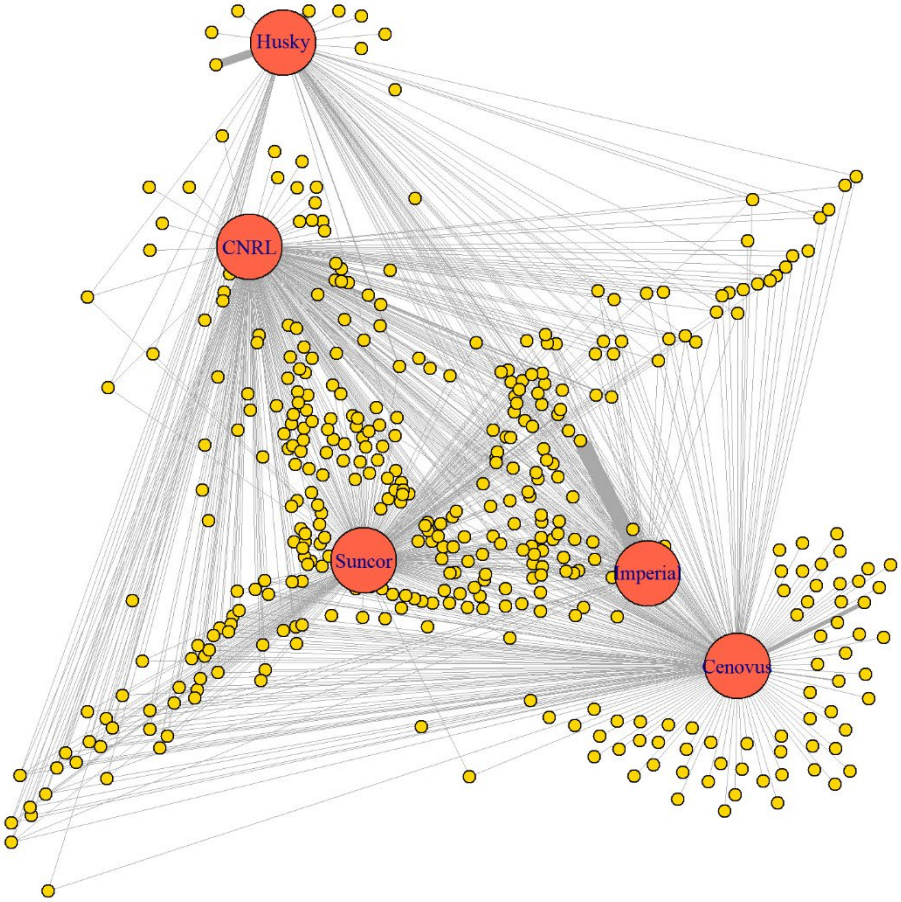
1b Financial Metrics as a Proportion of Gross Revenue					
Corporation	Cenovus	CNRL	Husky	Imperial	Suncor
Operating Revenue	20,895	21,161	22,843	34,964	38,952
Gross Profits	47.70%	69.50%	36.30%	20.90%	58.90%
Direct Costs	52.30%	30.50%	63.70%	79.10%	41.10%
Depreciation & Amortization	10.20%	24.40%	11.30%	4.40%	14.70%
Net Profits	-12.80%	12.20%	6.20%	6.60%	8.50%

Financial fundamentals are exported from the *Orbis* database as of June 2019. Values for total assets are, market capitalization, operating revenue, net income, and market price, presented in 1a Financial Fundamentals, are in 1,000s of Canadian dollars. Values in 1b Financial Metrics as a Proportion of Gross Revenue are presented as a percentage of the firms operating revenue. Financial fundamentals indicate that there is substantial heterogeneity among the Big Five fossil fuel firms.

We turn next to our sample of shareholders. The network in Figure 4-1 visualizes the distribution of all shareholders across the sample. The model has a total of 3,899 edges and 438 vertices. Fossil fuel corporations are denoted by the large light grey nodes, and the shareholders are denoted by the dark grey nodes. The size of the yellow nodes is proportional to the average percent of ownership in the respective firm over the sample period. The purpose of this network is to demonstrate the complex interrelations between the Big Five and shareholders. There is a notable concentration of shareholders who invest in all the Big Five (concentrated in the center), shareholders who invest in several but not all the Big Five (for example the cluster concentrated between CNRL and Suncor) and other shareholders who strictly invest in one of the Big Five (concentrated around the edges). The measure of degree centrality is 0.563.

Table 4-2 presents an overview of the evolution of institutional ownership and network centrality from 2009 to 2018. We trace the number of unique investors, as well as network-level degree centrality and closeness. Over our period of analysis, the total number of investors with holdings greater than 0.01 percent increased almost every year, from 159 to 176. However, the trends in the centrality measures varied considerably. The evolution in the number of shareholders within the sample over time follows periods of growth and contraction within the industry. Between 2009 to 2011, and 2015 to 2017 the average degree centrality and closeness centrality of shareholders fell. This indicates that shareholders may have divested their holdings from select firms during periods of contraction in the industry. Conversely, degree and closeness centrality increased between 2012 to 2014, during a period of economic growth and consolidation within the industry.

Figure 4-1 Network model of all shareholders in the Big Five



Network model of the Big Five fossil fuel firms in Canada. Ownership data is exported from the *Orbis* database as of June 2019. Red nodes represent fossil fuel companies. Yellow Nodes represent shareholders. Edge thickness represents the size of holdings.

Table 4-2 Overview of Investors and Network Centrality greater than 0.01%

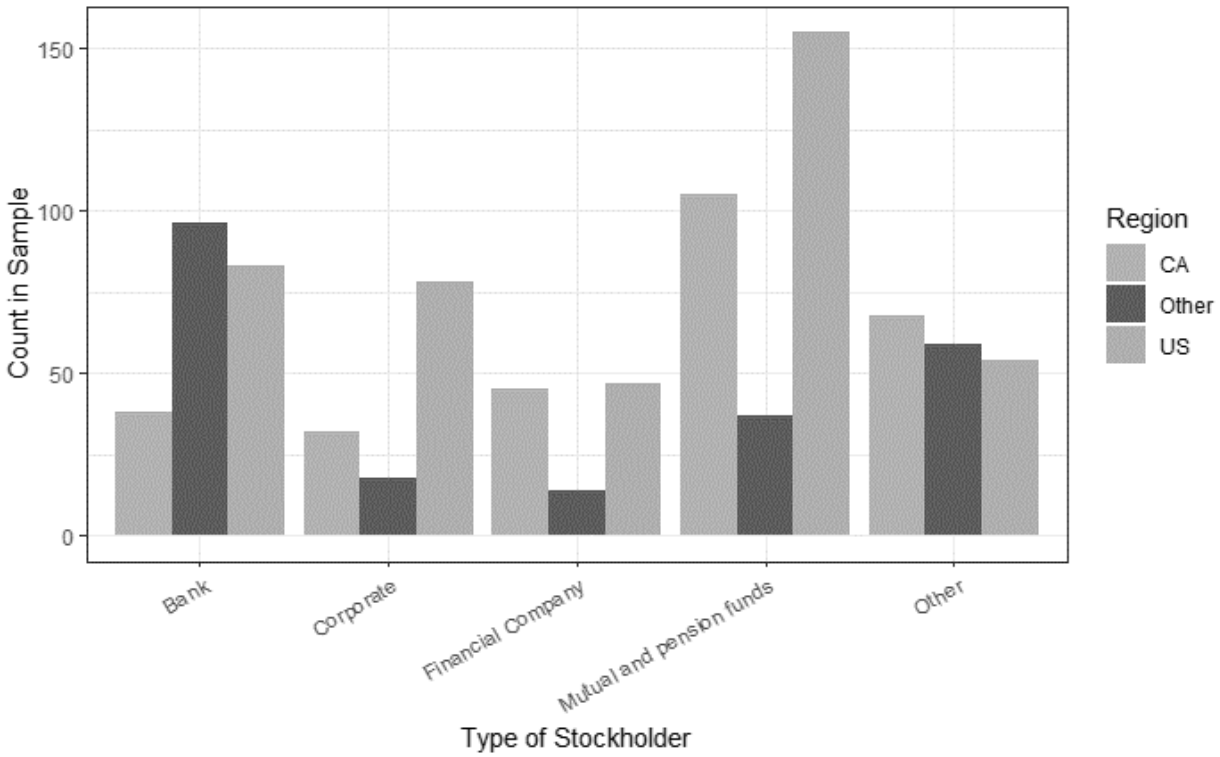
Year	Number of Investors	Degree	Closeness
2009	159	0.649	0.378

2010	160	0.597	0.308
2011	166	0.541	0.277
2012	167	0.567	0.305
2013	168	0.598	0.330
2014	169	0.652	0.389
2015	164	0.636	0.349
2016	174	0.590	0.318
2017	166	0.553	0.284
2018	176	0.561	0.313

Ownership data is exported from the *Orbis* database as of June 2019. Data is collected at an annual interval, over the course of ten years. The number of investors column presents the total number of distinct investors with greater than 0.01 percent holding in any of the Big Five. The degree column presents the density of the network, based on the average number of edges each node has, divided by the total number of edges in the network. The closeness column presents the average distance between two nodes, aggregated by year.

Shareholder attributes are also extracted from the *Orbis* database. Shareholders' types are categorized by banks, corporate entities, mutual and pension funds, financial companies, and others. Regions are categorized by headquarters in Canada, the United States, or other foreign ownership outside of Canada and the United States. Banks, corporate entities, mutual and pension funds, and financial companies account for 80 percent of all shareholders; and 76 percent of shareholders are headquartered in either Canada or the United States. Figure 4-2 presents the distribution of ownership of all shareholders over the past decade by region and business type. In line with Carroll and Huijzer (2018), we find that a sizable portion of equity ownership is held by foreign firms, of which the United States is among the most prevalent. In contrast to Carroll and Huijzer (2018), however, most institutional investors are not based on Canada. This suggests that larger fossil fuel firms may be significantly more exposed to global markets than smaller companies, that are more frequently owned by domestic shareholders.

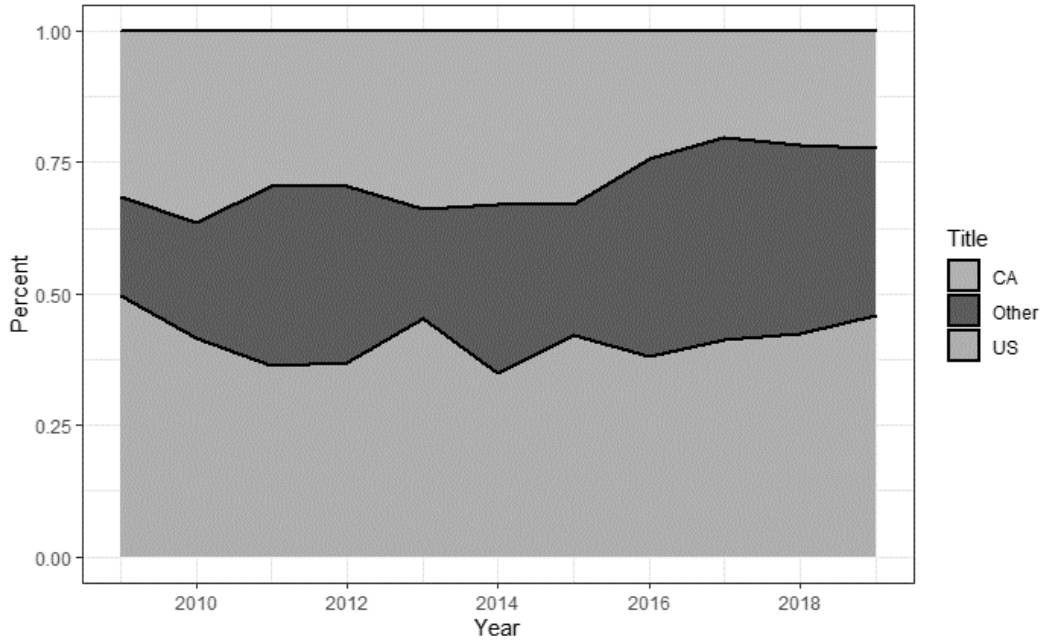
Figure 4-2 Shareholder attributes by region and by type



Distribution of shareholders by type and region. Data on shareholders is exported from the *Orbis* database as of June 2019.

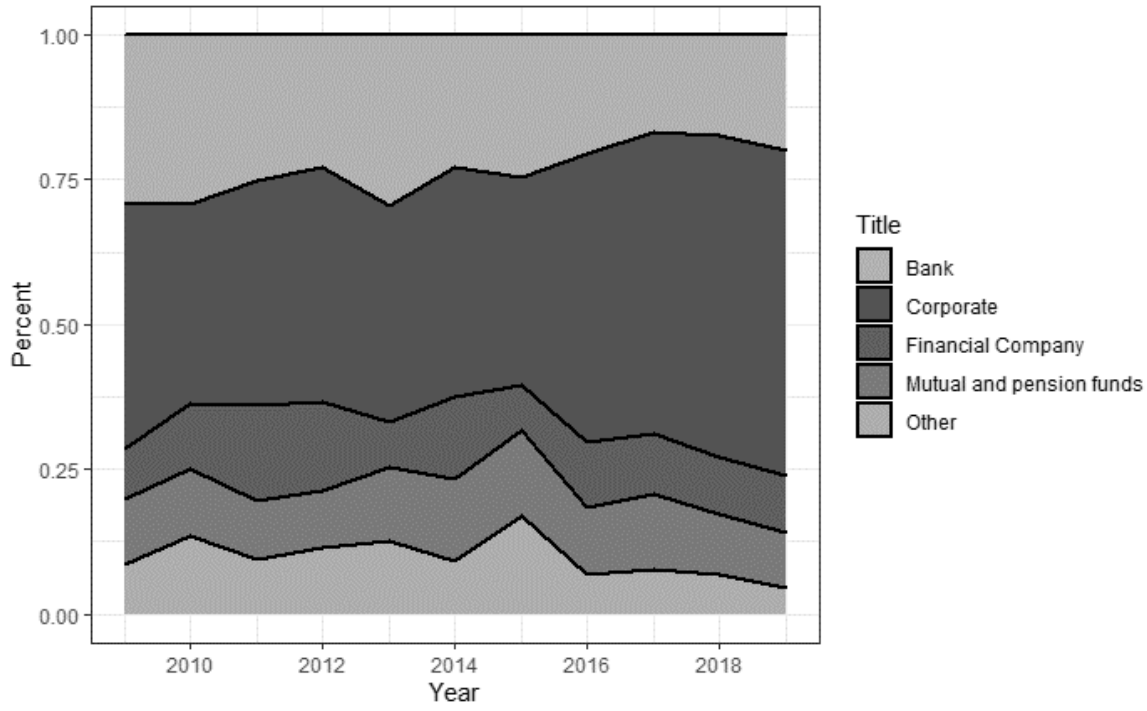
Similarly, in contrast to Carroll and Huijzer's (2018) findings, we find that Canadian ownership has declined substantially over time within the Big Five as foreign and corporate ownership has grown (Figure 4-3 and Figure 4-4). US ownership fell by 4 percent, Canadian Ownership fell by 9 percent, and foreign ownership increased by 13 percent over the period of analysis. American shareholders account for a significant proportion of ownership, averaging 40 percent of share ownership over 2009 to 2019. By type, bank ownership decreased by 9 percent while corporate ownership increased by 13 percent. Corporate ownership in 2019 accounts for the largest proportion (56 percent) of share ownership. These results speak to the exportation of equity ownership outside of Canada, to investors who may be less scrupulous about achieving Canada's climate commitments.

Figure 4-3 Evolution of Shareholder ownership by region



Distribution of shareholders by region over time. Data on shareholders is exported from the Orbis database as of June 2019.

Figure 4-4 Evolution of Shareholder ownership by business type



Distribution of shareholders by type over time. Data on shareholders is exported from the *Orbis* database as of June 2019.

Prevalent Shareholders

In line with Carroll and Hujizer (2018), we next conduct a stepwise reduction of ownership from 1 percent to 10 percent, to understand the characteristics of major shareholders in the Big Five (Table 4-3). We find that approximately 80 percent of shareholders own less than 1 percent of shares in the Big Five. Thus, significant proportions of ownership remain consolidated among a few shareholders. Owners with greater than 5 percent holdings in the Big Five (which is the proportion of ownership of a blockholder) account for 3 percent to 5 percent of shareholders. American and corporate entities make up the majority of blockholders. Corporate ownership is significantly more prevalent among the Big Five than the industry, indicating again that the Big Five have a substantially different ownership structure than other Canadian fossil fuel firms.

Table 4-3 Stepwise reduction of ownership in the big five

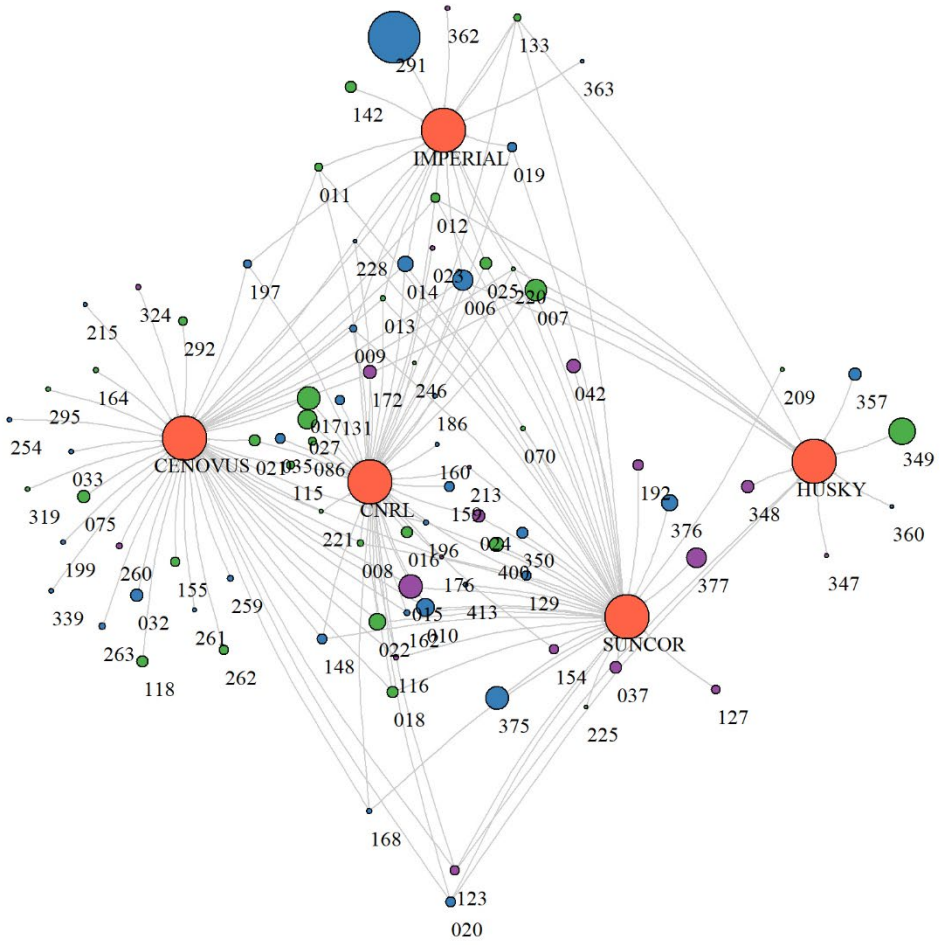
Minimum Ownership Stake	Firms in Network	Banks	Corporate	Mutual/ Pension Funds	Financial Company	Other	US	CA	Other
Total	273	102	45	53	24	49	109	98	66
1%	62	25	13	11	7	6	26	26	10
2%	38	14	12	9	2	1	18	14	6
3%	22	7	10	4	1	0	11	7	4
4%	15	3	10	1	1	0	8	3	4
5%	12	2	9	0	1	0	6	2	4
6%	10	1	8	0	1	0	5	1	4
7%	9	0	8	0	1	0	5	1	3
8%	9	0	8	0	1	0	5	1	3
9%	9	0	8	0	1	0	5	1	3
10%	8	0	7	0	1	0	4	1	3

The stepwise reduction table presents the number of owners by shareholder type that have at least a certain percent of ownership in the Big Five. Owners are delineated by their type and by their region of headquarters. We delineate owners with greater than 5 percent as block holders.

The network in Figure 4-5 visually depicts ownership greater than 1 percent. We note that the sample size is smaller and more fragmented than the network presented in Figure 4-1; there are a total of 750 unique links and a degree centrality of 0.106. Fossil fuel corporations are denoted by the red nodes, and the shareholders are mapped by their region (Figure 4-5) and type (Figure 4-6)

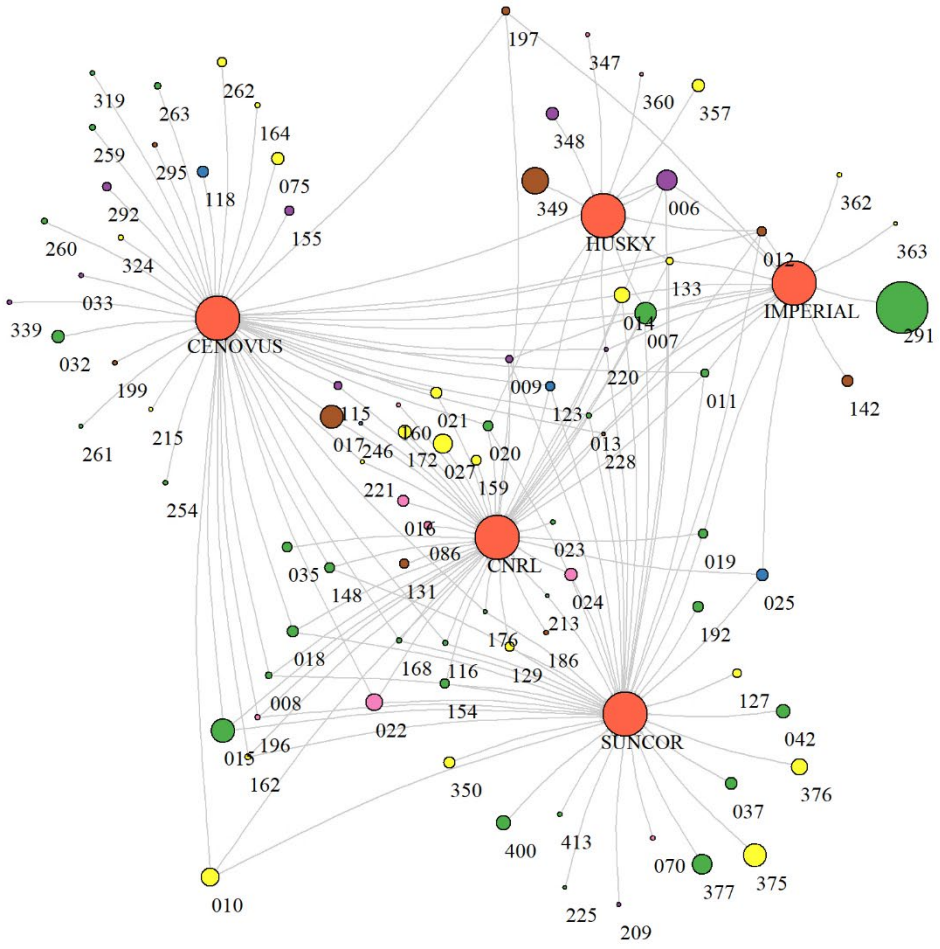
respectively. The size of the shareholder nodes is proportional to the average percent of ownership in the respective firm over the sample period.

Figure 4-5 Network model of shareholders with greater than 1% ownership, by region



Network model of the shareholders of Big Five fossil fuel firms with greater than 1 percent ownership, by the region where the shareholder's headquarters are based. Ownership data is exported from the *Orbis* database as of June 2019. Red nodes represent fossil fuel companies. Blue nodes represent American shareholders. Green nodes represent Canadian shareholders. Purple nodes represent shareholders from other regions.

Figure 4-6 Network model of shareholders with greater than 1% ownership, by type



Network model of the shareholders of Big Five fossil fuel firms with greater than 1 percent ownership, by shareholder type. Ownership data is exported from the *Orbis* database as of June 2019. Red nodes represent fossil fuel companies. Blue nodes represent Insurance. Green nodes represent Corporate shareholders. Purple nodes represent banks. Yellow nodes represent mutual funds, pension funds, and trusts. Brown nodes represent Financial Companies. Pink nodes represent other types of shareholders.

Table 4-4 comparably presents an overview of the evolution of institutional ownership and network centrality from 2009 to 2018, for those blockholders with greater than 5 percent

ownership. Over our period of analysis, the total number of blockholders increased almost every year, from 5 blockholders to 11 blockholders. There is no consistency in measures of degree centrality or closeness, however, both values are lower than the total sample. Overall, over the period of analysis, the number of blockholders has increased and remained relatively fragmented.

Table 4-4 Overview of Investors and Network Centrality greater than 5%

Year	Number of Investors	Degree	Closeness	Blockholders
2009	5	0.233	0.083	Blackrock; Capital Group; Exxon Mobil; FMR; Hutchison Whampoa
2010	7	0.371	0.098	Blackrock; Capital Group; Exxon Mobil; Hutchison Whampoa; Power Corporation of Canada; Power Financial Corp; Royal Bank of Canada
2011	6	0.218	0.075	Blackrock; Capital Group; FMR; Hutchison Whampoa; L.F. Investments; Royal Bank of Canada
2012	6	0.236	0.033	Blackrock; Exxon Mobil; FMR; Hutchison Whampoa; L.F. Investments; Royal Bank of Canada
2013	6	0.218	0.092	Blackrock; Exxon Mobil; FMR; Hutchison Whampoa; Power Corporation of Canada; Royal Bank of Canada
2014	9	0.170	0.060	Capital Group; Desmarais Family Residuary Trust; Exxon Mobil; FMR; Hutchison Whampoa; L.F. Investments; Power Corporation of Canada; Royal Bank of Canada
2015	7	0.129	0.011	Capital Group; Exxon Mobil; FMR; Hutchison Whampoa; Power Corporation of Canada; Royal Bank of Canada; T. Rowe Price Group
2016	8	0.276	0.030	Capital Group; Exxon Mobil; FMR; Hutchison Whampoa; L.F. Investments; Royal Bank of Canada
2017	8	0.229	0.039	Capital Group; Capital Research Global Investors; ConocoPhillips; Exxon Mobil; FMR; Hutchison Whampoa; L.F. Investments; Royal Dutch Shell
2018	8	0.279	0.050	BPCE; Capital Group; ConocoPhillips; Exxon Mobil; FMR; Hutchison Whampoa; L.F. Investments; Royal Bank of Canada

Ownership data is exported from the *Orbis* database as of June 2019. Data is collected at an annual interval, over the course of ten years. The number of investors column presents the total number of distinct investors with greater than 5 percent holding in any of the Big Five. The degree column presents the density of the network, based on the average number of edges each node has, divided by the total number of edges in the network. The closeness column presents the average distance between two nodes, aggregated by year. The blockholders column presents owners with greater than 5 percent ownership, by year.

We identify the most prevalent shareholders, as entities with the size and potential to influence the Big Five corporations. Some common entities have been aggregated, as explained in the methods above. In total, we identify 14 companies that have or had influential leverage in the Big Five and

consequently in the oil sands industry, over our period of analysis. Table 4-5 lists what we denote as prevalent shareholders, as entities that have or had over 5 percent ownership in any one or more of the Big Five corporations. Corporations are ranked by the number of companies in which they own shares (ownership breadth), the number of holdings greater than 5 percent (block holding power), and average ownership share.

As our data shows, prevalent shareholders are comprised of a variety of business types across several regions. Six of the prevalent shareholders are based in the United States, three are based in Canada, and four are based in Europe. Thus, over 70 percent of prevalent shareholders are based outside of Canada. Banks and corporations similarly encompass over 70 percent of prevalent shareholder types. Notably, three fossil fuel corporations, Exxon, ConocoPhillips, and Royal Dutch Shell also own sizeable portions of Imperial, Husky, and CNRL respectively. Six of the prevalent shareholders have ownership of all five companies, of which five have individual block holdings (as greater than 5 percent of shares) in at least three companies. We denote the top five entities (Capital Group, FMR (Fidelity), Blackrock, Royal Bank of Canada, and Power Corporation of Canada) as the "financial giants", to further differentiate their leverage among the prevalent shareholders. These shareholders have the potential to coordinate their corporate control by voting to influence business operations in the Big Five.

Table 4-5 List of prevalent shareholders denoted by holdings greater than 5%

	Shareholder	**Location**	**Category of Shareholder**	**Ownership Breadth**	**Number of Holdings >5% Companies**	**Average ownership share**
1	Capital Group	US	Corporate	5	(3) Cenovus, CNRL, Suncor	4.64%
2	FMR	US	Corporate	5	(3) Cenovus, CNRL, Suncor	3.59%

3	Blackrock	US	Bank	5	(3) Cenovus, CNRL, Suncor	2.87%
4	Royal Bank of Canada	CA	Bank	5	(3) Cenovus, CNRL, Suncor	3.46%
5	Power Corporation of Canada	CA	Financial company	5	(3) Cenovus, CNRL, Suncor	2.14%
6	Desmarais Family Residuary Trust	CA	Mutual and pension fund	5	(1) Cenovus	3.02%
7	T. Rowe Price Group	US	Bank	4	(1) CNRL	1.08%
8	BPCE	FR	Bank	2	(1) Cenovus	2.34%
9	Exxon Mobil	US	Corporate	1	(1) Imperial	66.04%
10	Hutchison Whampoa	LU	Corporate	1	(1) Husky	36.46%
11	L.F. Investments	LU	Financial company	1	(1) Husky	32.06%
12	ConocoPhillips	US	Corporate	1	(1) Cenovus	16.93%
13	Capital Research Global Investors	US	Mutual and pension fund	1	(1) CNRL	11.70%
14	Royal Dutch Shell	GB	Corporate	1	(1) CNRL	8.86%

The top influential shareholders are measured using a combination of ownership breadth (the number of firms the shareholder has a holding of at least 0.01 percent) and by their blockholding power (the number of firms the shareholder has a holding of at least 5 percent. Average ownership share is calculated based on the shareholder's holdings in all five companies. The shareholder's location and stakeholder type are also presented.

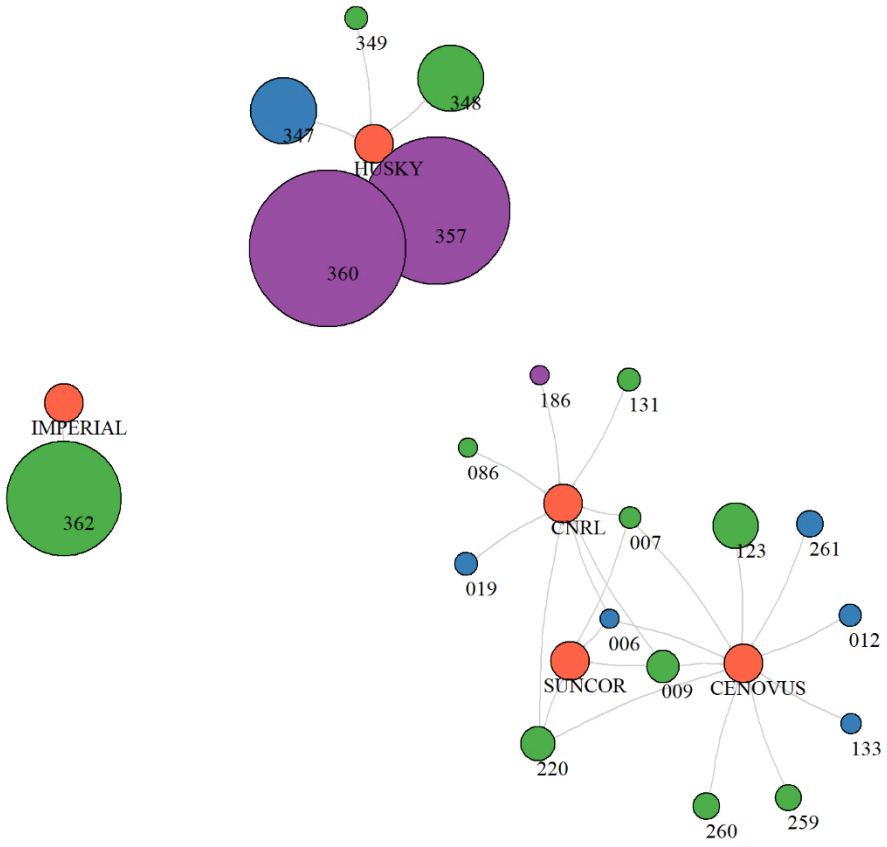
Complementing the list of major shareholders, we conduct a brief small-sample investigation on the positions of major shareholders in the Big Five. We find unsurprisingly that many of these block holders maintain a position of engagement over divestment. Capital Group explicitly cites that the "world's energy needs cannot be met with alternative sources alone [and] more conventional forms of energy will still be needed" (Capital Group, 2016, p. 2). Yet, Share Action's 'Voting Matters 2020' report scored Capital group against 52 percent of shareholder resolutions, scoring amongst the bottom of the ranking of asset managers (Martin & Brooks, 2020). Blackrock in contrast, had taken a clear position on divesting from climate change laggards (Fink, 2020), but remains a major investor in all five fossil fuel firms. Blackrock also voted against 87 percent of shareholder resolutions examined by Share Action in 2020. Fidelity similarly voted against 57 percent of these shareholder resolutions. In Canada, the Royal Bank of Canada maintains that the best approach to support the transition to a low-carbon economy is through active stewardship

(Royal Bank of Canada, 2021). Power Corporation of Canada similarly maintains their position, asserting that ownership enables them to contribute positively to the investee companies' ESG progress, while divestiture may not allow meeting this goal (Power Corporation of Canada, 2018, p. 59). T Rowe Price Group offers fossil free funds for investors who are more environmentally conscious, yet voted in favour of climate-related shareholder resolutions a paltry 16 percent of the time (Berridge, 2019). Three shareholders on the list are fossil fuel firms, including Exxon Mobil, which has a long history of climate disinformation and denial (Supran & Oreskes, 2017, 2021). Other, blockholders like the Desmarais Family Trust do not take a formal position on divestment or engagement but are tightly knit to the Power Corporation of Canada, where Paul Desmarais served as the chair. Collectively, it appears that even where climate change risk is acknowledged, common rhetoric of delay through criticisms of divestment and reference to energy demand, continue to be used to maintain their positions of influence among the Big Five.

We finally map the blockholders (Figure 4-7 and Figure 4-8), to visually depict ownership greater than 5 percent. We see through these visualizations that while Cenovus, CNRL, and Suncor share common blockholders, Husky is controlled by 5 disconnected blockholders and Imperial is controlled by one large disconnected blockholder. There are a total of 25 unique links and a degree centrality of 0.023. The size of the shareholder nodes is proportional to the average percent of ownership in the respective firm over the sample period. Fossil fuel corporations are denoted by the red nodes, and the shareholders are mapped by their region (Figure 4-7) and type (Figure 4-8) respectively. The ownership dynamics between CNRL, Suncor, and Cenovus versus those of Husky and Imperial, are a visually relevant representation of connected and disconnected subnetworks. In this case, shareholders with high betweenness centralities might be well suited to adopt different forms of engagement, such as coordinated collective action (Dimson et al., 2021),

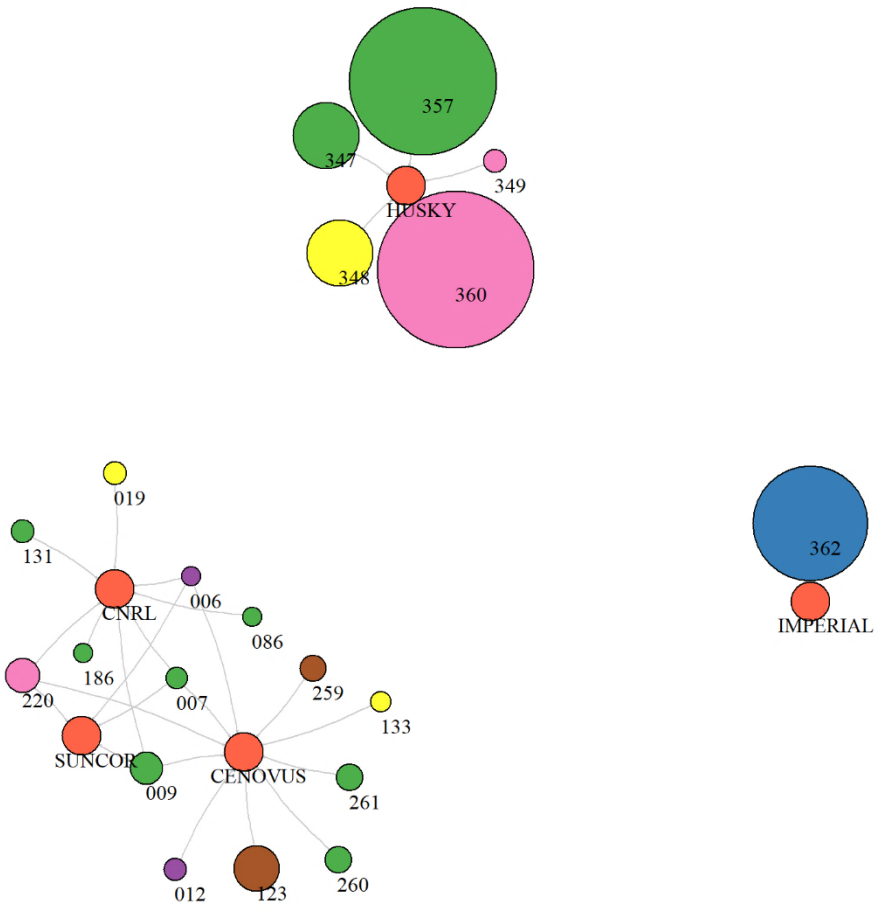
to drive change within these firms. The type and region of shareholder can also influence strategy, as each shareholder might have a different fiduciary duty or be held to different regulations.

Figure 4-7 Network model of shareholders with greater than 5% ownership, by region



Network model of the shareholders of Big Five fossil fuel firms with greater than 1 percent ownership, by the region where the shareholder's headquarters are based. Ownership data is exported from the Orbis database as of June 2019. Red nodes represent fossil fuel companies. Blue nodes represent American shareholders. Green nodes represent Canadian shareholders. Purple nodes represent shareholders from other regions.

Figure 4-8 Network model of shareholders with greater than 5% ownership, by type



Network model of the shareholders of Big Five fossil fuel firms with greater than 1 percent ownership, by shareholder type. Ownership data is exported from the *Orbis* database as of June 2019. Red nodes represent fossil fuel companies. Blue nodes represent Corporate shareholders. Green nodes represent Insurance. Purple nodes represent financial companies. Yellow nodes represent mutual funds, pension funds, and trusts. Brown nodes represent banks. Pink nodes represent other types of shareholders.

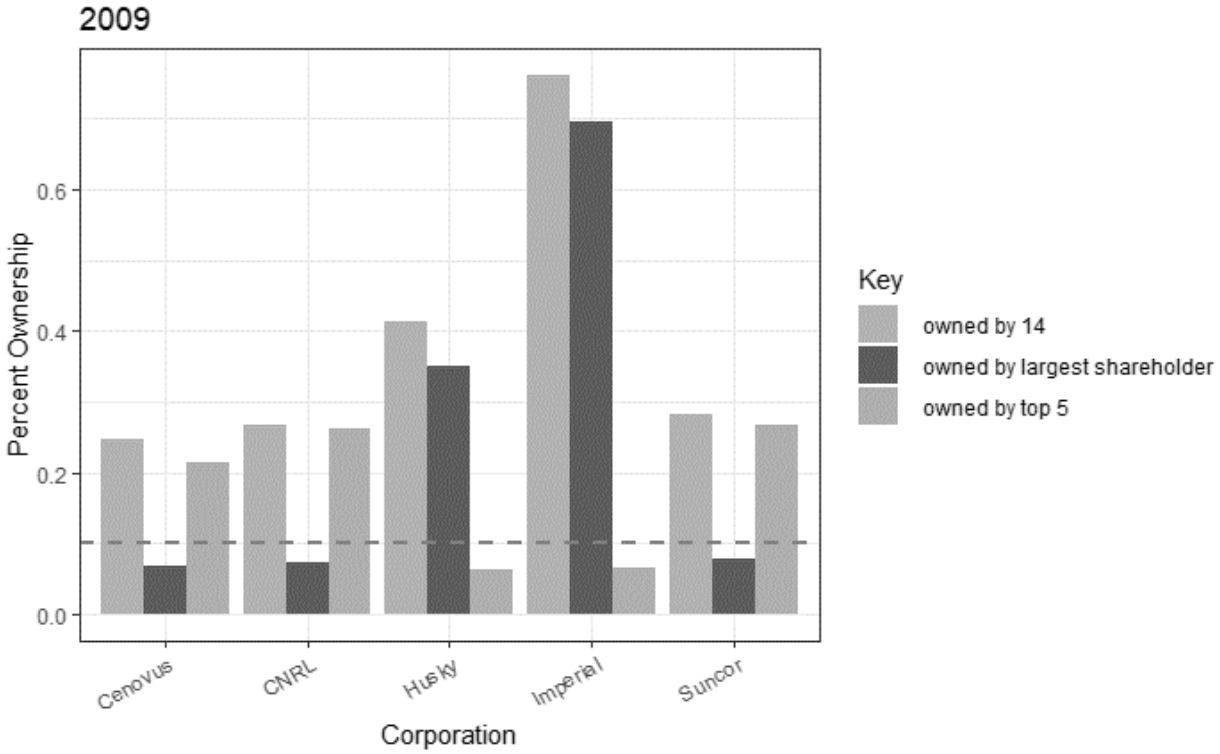
Prevalent shareholders can collectively influence business operations of the Big Five in favour of climate stability. Therefore, we calculate the aggregated ownership of these prevalent shareholders

for each of the Big Five corporations. Following Galaz et al., (2018) we select a 10 percent ownership level to indicate considerable influence in corporate governance.

Prevalent shareholders collectively hold ownership above the 10 percent threshold in all five corporations (Figure 4-9 and Figure 4-10). As of 2018, the top 14 shareholders identified above held 17 percent of Suncor, 24 percent of CNRL, 51 percent of Cenovus, 72 percent of Husky, and 73 percent of Imperial. Moreover, the top 5 financial giants collectively hold over 10 percent ownership in Cenovus, CNRL, and Suncor, at 28, 23, and 17 percent respectively. The top shareholders of Cenovus, CNRL, Husky, and Imperial (ConocoPhillips at 17 percent, Capital Research Global Investors at 11 percent, Hutchison Holdings at 40 percent, and ExxonMobil at 70 percent) individually held over 10 percent ownership in their respective corporations. Therefore, we infer that in all the Big Five corporations, the collective influence of prevalent stakeholders can control the business operations and corporate governance of the companies, however, ownership dynamics do differ in who and how many shareholders hold influence.

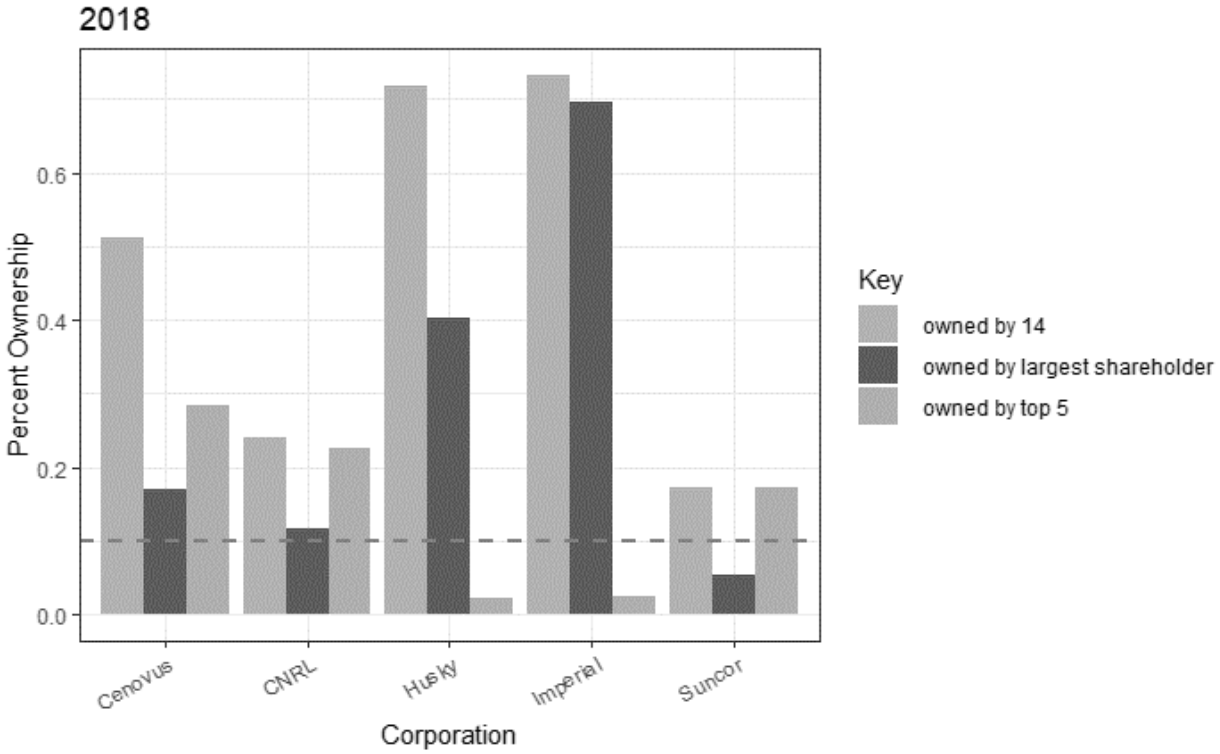
There are some slight changes in control over time. The total share of ownership increased on all accounts for Cenovus, mot recognizably through the purchase of ConocoPhillips' Canadian assets in 2017 (Morgan, 2017). Between 2009 to 2019, total ownership by prevalent shareholders increased by 26 percent, suggesting that Cenovus saw more concentrated control of power among its shareholders. On the contrary, ownership in Suncor diversified over the period of 2009 to 2019, as the total share of ownership by prevalent shareholders fell by 11 percent. On average, ownership by prevalent shareholders increased by 8 percent across the Big Five.

Figure 4-9 Prevalent shareholder influence over time (2009)



Total percent ownership in the Big Five by groups of shareholders in 2009. Data on shareholders is exported from the *Orbis* database as of June 2019. The Top 14 are identified in Table 4-5 as Capital Group, FMR, Blackrock, Royal Bank of Canada, Power Corporation of Canada, Desmarais Family Residuary Trust, T. Rowe Price Group, BPCE, Exxon Mobil, Hutchison Whampoa, L.F. Investments, ConocoPhillips, Capital Research Global Investors, and Royal Dutch Shell. The Top 5 are delineated as Capital Group, FMR, Blackrock, Royal Bank of Canada, and Power Corporation of Canada. As of 2009, the largest shareholder in Cenovus is Blackrock with 6.73%. The largest shareholder in CNRL is Blackrock with 7.25%. The largest shareholder in Husky is Hutchison Whampoa with 35%. The largest shareholder in Imperial is Exxon Mobil with 69.6%. The largest shareholder in Suncor is Capital Group with 7.89%.

Figure 4-10 Prevalent shareholder influence over time (2018)



Total percent ownership in the Big Five by groups of shareholders in 2018. Data on shareholders is exported from the *Orbis* database as of June 2019. The Top 14 are identified in Table 4-5 as Capital Group, FMR, Blackrock, Royal Bank of Canada, Power Corporation of Canada, Desmarais Family Residuary Trust, T. Rowe Price Group, BPCE, Exxon Mobil, Hutchison Whampoa, L.F. Investments, ConocoPhillips, Capital Research Global Investors, and Royal Dutch Shell. The Top 5 are delineated as Capital Group, FMR, Blackrock, Royal Bank of Canada, and Power Corporation of Canada. As of 2018, the largest shareholder in Cenovus is ConocoPhillips with 16.93%. The largest shareholder in CNRL is Capital Group with 11.76%. The largest shareholder in Husky is Hutchison Whampoa with 40.19%. The largest shareholder in Imperial is Exxon Mobil with 69.59%. The largest shareholder in Suncor is FMR with 5.22%.

Sensitivity to Shareholders

We next examine the sensitivity to shareholders based on Galaz et al.'s (2018) methodology. We begin by calculating the Herfindahl-Hirschman Index (HHI), as a measure of the concentration of equity ownership across all shareholders. The HHI measures the concentration of equity ownership for each of the selected companies (Table 4-6). Alternatively, the HHI can be understood as a measure of diversity in equity ownership. High concentrations of ownership equate to higher values on the HHI.

$$HHI = \sum_{i=1}^{N} {s_i}^2$$

Where, s_i is the share percentage of shareholder i, expressed as a whole number.

We calculate the HHI over time to examine how the concentration of equity ownership has changed over the last commodity cycle. Table 4-6 shows that concentration varies considerably between the Big Five, with Husky and Imperial being highly concentrated. Changes in concentration were most prominent in Cenovus and Husky, which increased by 438 percent and 230 percent respectively from 2009 to 2019. In contrast, concentration fell by 27 percent for Suncor over that period. On average, the HHI increased by 54 percent, from under 1340.5 to over 2062.2.

Table 4-6 Herfindahl-Hirschman Index over time

Corporation	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009
Cenovus	259.7	275.7	461.3	337.0	298.6	183.7	166.3	266.1	191.4	304.5	221.8
CNRL	943.4	1076.9	591.5	208.5	322.5	257.6	357.1	208.0	233.6	274.6	175.4
Husky	4087.9	5244.9	5235.4	5243.3	1170.4	3596.9	1169.2	3565.8	3672.4	1253.9	1239.9
Imperial	4870.6	4874.9	4874.7	4874.9	4870.1	4869.4	4858.5	4854.8	2516.2	2520.3	4862.2
Suncor	149.2	264.4	175.5	200.1	246.1	260.7	297.1	220.6	260.9	289.9	203.4
Average	2062.2	2347.4	2267.7	2172.8	1381.5	1833.7	1369.6	1823.0	1374.9	928.7	1340.5

The Herfindahl-Hirschman Index (HHI) are calculated at the firm level for each of the Big Five in the sample, over the course of ten years. Higher HHI scores indicate greater concentration of ownership among few prominent shareholders.

The book debt to capital ratio is a measure of a company's financial leverage. It is a representation of how heavily the company relies on debt financing and consequently, how sensitive the company is to external financing (Galaz et al., 2018). We calculate the book debt to capital ratio (D⁄C) as follows:

$$D/C = \frac{\sum_{i=0}^{n} D_i}{\sum_{i=0}^{n}(D_i + E_i)}$$

Where, n is the number of companies in the sample, D_i is the total debt (short term and long term), and E_i is shareholder equity.

Table 4-7 presents the total book debt to capital of the Big Five, compared to the industry average. All five corporations rely heavily on debt to finance their business operations, primarily to finance the high costs of plant and machinery associated with production. The debt to capital ratio of the Big Five is considerably higher than the global average, suggesting that the Big Five has a higher debt load than its international counterparts.

Table 4-7 Market Debt to Capital Ratio

Corporation	Fixed Assets	Current Liabilities	Shareholder Equity	Debt to Capital
Cenovus	15,423	1,397	9,387	64%
CNRL	34,695	2,559	17,183	68%
Husky	13,865	2,684	10,541	61%
Imperial	18,393	2,125	13,161	61%
Suncor	30,193	5,540	23,649	60%
Average	22,514	2,861	14,784	63%
Market debt to capital in Oil/Gas (Production and Exploration) among Global companies				29.18%

The debt-to-capital ratio are calculated at the firm level for each of the Big Five firms in the sample. A high debt to capital ratio indicates that the firm is more highly leveraged, perhaps due to high fixed capital costs associated with infrastructure development. The debt-to-capital ratio is calculated by adding fixed and current liabilities and dividing that value by shareholder equity.

The HHI and debt to capital ratio indicates considerable heterogeneity in the Big Five fossil fuel firms, both in how their ownership is structured and by how leveraged they are. This indicates that points of intervention will differ not only by shareholder characteristics but by firm characteristics as well.

Ranking Shareholders by Influence

We conclude with a novel ranking method that combines equity ownership data with sensitivity metrics. We assert based on Galaz et al., (2018), that owners with holdings in firms that are highly leveraged, highly concentrated, and with higher potential emissions are more susceptible to shareholder intervention and thus, those factors should be considered when evaluating shareholder influence. Consequently, in light of the wide disparity in sensitivity scores identified above, evaluating influence simply on the size of equity holdings or number of holdings would be misguided. More, the emissions potential of the Big Five also vary considerably. CNRL's proven reserves would produce over 1.7 gigatons of carbon emissions, while Husky's reserves would only produce 0.3 gigatons of carbon emissions (Fossil Free Funds, 2020). Cenovus, Imperial, and Suncor would produce 0.65, 0.60, and 0.69 gigatons respectively (Fossil Free Funds, 2020). Consequently, the firms proven reserves should also be considered when evaluating the potential influence of a shareholder in reducing carbon emissions. Multiplying ownership in each firm by the firm's sensitivity scores and emissions potential provide a unique look at who the most influential shareholders are, not only by their ownership but by firm and climatic factors as well. It should be noted that the final score is, in itself, an arbitrary ranking indictor that does not in itself represent the shareholder or the firm. Table 4-8 presents the list of shareholder ranking, based on this new measure.

Table 4-8 Ranking of Ownership Influence by Size of Holding and Firm Sensitivity

	Cenovus	**CNRL**	**Husky**	**Imperial**	**Suncor**
Debt-to-Capital	0.64%	0.68%	0.61%	0.61%	0.61%
HHI	943.41	259.70	4087.94	4870.61	149.23
Emissions Potential	0.65 GT	1.72 GT	0.30	0.60%	0.68

Firm	Cenovus	CNRL	Husky	Imperial	Suncor	Score
Exxon Mobil	0.00%	0.00%	0.00%	69.59%	0.00%	124,782
Hutchison Whampoa	0.00%	0.00%	40.19%	0.00%	0.00%	30,471
L.F. Investments	0.00%	0.00%	29.32%	0.00%	0.00%	22,230

Capital Group Co	13.50%	11.76%	0.00%	0.00%	4.93%	9,259
ConocoPhillips	16.93%	0.00%	0.00%	0.00%	0.00%	6,714
Royal Bank of Canada	2.39%	5.18%	0.65%	1.80%	4.24%	6,518
FMR	9.29%	2.97%	0.84%	0.53%	5.22%	6,506
Artisan Partners Asset Management	0.00%	0.00%	0.00%	3.45%	0.00%	6,186
First Eagle Investment Management	2.13%	0.00%	0.00%	2.87%	0.00%	5,991
Vanguard Group	2.41%	2.90%	0.78%	0.94%	3.03%	4,309

The ranking of the most influential shareholders is measured using a combination firm dynamics and ownership size. Total ownership in each firm is multiplied by the debt to capital ratio, HHI, and emissions potential, to estimate how influential a shareholder might be, given the heterogeneity of firm characteristics.

Using this metric, Exxon Mobil is among the most influential shareholder, given their substantive and monopolistic holding in Imperial Oil, followed by Hutchinson Whampoa and LF Investment group for their holdings in Husky. Both Husky and Imperial have a higher firm sensitivity score, given their inordinately high HHI. This list is followed by Capital Group, ConocoPhillips, Royal Bank of Canada, FMR, Artisan Partners Asset Management, and First Eagle Investment Management. Notable, under this ranking, firms like Vanguard (ranked 10) and Blackrock (ranked 23), are perceived less influential, due to smaller holdings in more democratically owned firms. Certainly, one limitation of this method is the effect of coordinate engagement (Dimson et al., 2021), which might be considered in future research.

Our results thus present an in-depth view of firm and shareholders dynamics in Canada's Big Five fossil fuel companies, a necessary precursor to finding effective points of intervention. We find that the Big Five are highly heterogenous in their operations and their ownership structures. Consequently, the influence of shareholders will depend not only on their holdings, but on the firm that they wish to engage with as well.

4.5 Discussion

The results of this study contribute to theory and practice, bridging the literature on corporate governance and climate stability. It addresses the gap in research about whether major shareholders can influence the governance of fossil fuel firms and consequently how those activities may bolster or impede climate change efforts. By bridging shareholder dynamics with firm metrics, the study presents a novel contribution to the literature on corporate influence.

The collective influence of major shareholders in bolstering or impeding economic activities that contribute to climate instability is an area ripe for future research. In this study, we identified major shareholders in the Big Five and directly linked their holdings to anthropogenic climate change. We found that equity ownership in Canada's Big Five is highly consolidated, increasingly by foreign owners. Combining this with insights on firm sensitivity suggests that there is an intrinsic motivation for the industry and its shareholders to maintain status quo, to mitigate against the climate related financial risks of stranded assets. A high debt load exposes shareholders to higher financial risks associated with capital flight, diminishing asset values, and ultimately stranded assets; and thus, investors might be motivated to maintain favourable market conditions for those threatened assets. Consequently, it is doubtful that the industry will seriously commit to curtailing their production to mitigate climate change. Moreover, given the enormity of blockholders in Canada's fossil fuel industry, it is doubtful that the many institutional investors who advocate for engagement will be able to influence corporate governance, especially without the intention to divest. However, while many shareholders may not have the capacity to influence corporate governance, all investors who maintain their holdings remain susceptible to the risks of stranded assets.

Relating back to the literature on engagement, agency theory provides one explanation to why a shareholder may intervene in a firms' operations (Daily et al., 2003). This framework is traditionally applied to examining interventions that increase shareholder returns; however, as the industry continues to underperform, insights on proxy voting (Martin & Brooks, 2020), indicating that investors may not be meaningfully engaging with the fossil fuel industry. More, the theory traditionally looks at means of increasing productive capacity, not decreasing reserves. Consequently, agency theory is inadequate in explaining why major shareholders maintain their investments and why they may not effectively engage in the fossil fuel industry. The capital as power theory (Nitzan & Bichler, 2009) in contrast asserts that investments are a forward-looking indicator of future profit and consequently, investors may be motivated to maintain favourable market conditions for their firms, to mitigate against the financial risks of stranded assets. Capital may thus be used in a manner that contradicts effective climate solutions, if those interventions are perceived to be of material financial risk to the investor or to the stability of the industry. This may explain why prominent shareholders like Capital Group maintain a position of engagement and active stewardship while concurrently voting against climate-related shareholder resolutions.

We conclude then, that engagement may not be an effective solution to addressing the climate crisis, as the industry and shareholders alike will work to maintain status quo. However, as the climate crisis worsens, increased and accelerated policy responses can be expected, which can result in asset stranding for shareholders that maintain their investments. High market-debt-to-capital among the Big Five exposes the firms and their shareholders to higher financial risks than their global counterparts. These firms are more likely to experience capital flight and face higher risk premiums during periods of market instability or accelerated policy response, which diminishes asset values and ultimately results in stranded assets.

Consequently, two future directions must be given greater prescience. First, fossil fuel divestment proves to be an increasingly prudent choice for most investors. Most investors don't have the financial capital or salience to meaningfully engage with the industry. Those that do, are unlikely to meaningfully engage to change operations due to the financial risks of stranded assets. Consequently, divestment is the prudent choice for shareholders who perceive physical, regulatory, and transitory risks to be material to the firm. These risks are exacerbated as divestment gains prevalence not only among investors, but lenders and insurers as well (Carter & Dordi, 2021; IEEFA, 2021). Furthermore, fossil free funds already prove to be competitive with their conventional counterparts; most studies in this field find a positive impact of fossil fuel divestment on the investors' returns (Ansar et al., 2013; Bauer et al., 2018; Braungardt et al., 2019; Dordi & Weber, 2019b; Henriques & Sadorsky, 2018; Hunt & Weber, 2018). We thus maintain that the large shareholders identified in our study might be able to reduce their exposure to high emitting investments without reducing their financial returns.

Second, greater impetus on the effectiveness of financial supervision must be considered (Campiglio et al., 2018; Dikau et al., 2020; Dikau & Volz, 2018; Durrani et al., 2020; Macaire & Naef, 2021). In line with (Nitzan & Bichler, 2009) and literature on the role of the financial sector in economic transitions (Perez, 2002), capital can also be used to re-shape society if the power is regulated accordingly by financial supervisors. Climate-related policy interventions might, for example, be able to direct capital toward a more sustainable direction that helps both restrict economic activities that contribute to climate instability while also mitigating financial risks. Investors with high exposure to climate risks could be required to report on climate-related key performance indicators to enable supervisors to manage climate-related risks for the stability of the financial sector. Hence it is in the interest of these investors to engage with their investees in

the fossil-fuel industry to convince them to adopt carbon reduction strategies (Sprengel & Busch, 2011), and, if the engagement does not change the carbon exposure, to reduce the investment. Such a strategy, conducted by powerful capital holders (Nitzan & Bichler, 2009) will help both, investors and investees, to reduce climate related financial risks.

5. TEN FINANCIAL ACTORS CAN ACCELERATE A TRANSITION AWAY FROM FOSSIL FUELS

This chapter is adapted from: Dordi, T., Gehricke, S. A., Naef, A., & Weber, O. (2022). Ten financial actors can accelerate a transition away from fossil fuels. Environmental Innovation and Societal Transitions, 44, 60-78.

5.1 Introduction

The burning of fossil fuels is the single largest source of global greenhouse gas emissions (Heede & Oreskes, 2016) and production is concentrated among a few large and highly influential fossil fuel firms (Ekwurzel et al., 2017). Just 200 companies, the Carbon Underground 200 (CU200), currently own 98 percent of global fossil reserves in the form of oil, gas, or coal (Fossil Free Funds, 2020). If these reserves are burned, it is estimated that it would generate an additional 674 gigatons of carbon emissions; 20 times greater than global carbon emissions in 2019 and three times greater than our global carbon budget (Matthews et al., 2021). Consequently, we cannot meet our global climate commitments without addressing the CU200.

The CU200 will play a key role in the energy transition toward a low-carbon energy-based regime (Jaccard et al., 2018; McGlade & Ekins, 2015; Virla et al., 2021). However, due to the significant inertia in favour of incumbent energy regimes (Chapman et al., 2021; Nykvist & Maltais, 2022), a proactive approach to transition management will be critical to accelerate the energy transition (Goddard & Farrelly, 2018). Within the multilevel perspective of transitions (Geels, 2002, 2005; Rip & Kemp, 1998; Schot et al., 1994), we pose that capital markets, as systemic intermediaries (Kivimaa et al., 2019; van Lente et al., 2011), have the capacity to disrupt existing socio-technical regimes and drive a low-carbon transition (Geddes & Schmidt, 2020; Naidoo, 2020; Nykvist & Maltais, 2022; Seyfang et al., 2010). More, we examine the role of capital markets as a critical context system (Bergek et al., 2015; Markard et al., 2021), which, through their influence on

resource mobilization (Bergek et al., 2008; Hekkert et al., 2007; Polzin et al., 2016), can influence business strategy of the CU200, in a manner that either hampers the desired decline of existing, or drives the emergence of alternative, systems of sustainable energy production.

Attested by Naidoo (2020), we contend that climate action requires grand-scale responses, and grand-scale responses require finance. Indeed, capital markets have historically been foundational in supporting economic (Perez, 2002) and sociotechnical (Loorbach et al., 2017) transitions, and will be vital in a low-carbon energy transition as well. Though the study of sustainable finance has burgeoned in recent years, literature on finance and sustainability transitions remains fragmented (Naidoo, 2020).

Literature on sustainability transitions to date, has largely focused on a redirection of financial capital away from incumbent regimes to enable transition (Geddes & Schmidt, 2020). However, the influence of the existing capital allocation in constraining or enabling sustainability transitions is equally pertinent; through active engagement in corporate governance, capital markets can influence the direction of unsustainable industries. Neglecting this key aspect of existing capital allocation can hamper the mobilization of critical resources and undermine sustainability transitions (Markard et al., 2021). Through engagement and divestment, capital markets are able to influence business strategy and curtail fossil fuel extraction (Hunt & Weber, 2018). Consequently, capital markets may prove not only to be opposing actors but important enablers to the innovation process (Fischer & Newig, 2016).

Furthermore, while capital markets have historically hindered transformative processes in the fossil fuel industry, recent pledges by investment managers to adopt responsible investment approaches and reduce carbon exposure is indicative of a shift in actor roles along sustainability transitions (Fischer & Newig, 2016). We extrapolate that as capital markets place greater pressure

on their investees to align their business practices with the investors' carbon reduction strategies, these efforts could result in the systemic restructuring of the fossil fuel industry. Consequently, capital markets have the potential to shift from a system that hinders a transition to one that could drive the emergence of more sustainable, low-carbon systems of production.

Finally, we posit that the potential influence of each independent shareholder will differ based on organizational characteristics (Markard, 2011), and consequently, successful points of intervention will also differ (Kanger et al., 2020). Interventions from an investment management firm with many small holdings will, for instance, differ from a government with few large holdings. Consequently, to effectively design policy solutions, we must first know who the most influential financial actors are.

Thus, this paper asks three questions. First, what are the organizational characteristics of prominent equity owners that invest in the CU200? Second, to study the resource mobilization function, we ask, *how* much influence do different types of equity owners have over the governance of the industry? Third, as potential enablers of socio-technical innovation, we ask, *who* are the equity owners that have the greatest potential impact on the governance of fossil fuel firms and what are their investment patterns? The results of the study will articulate the role of capital in the fossil fuel industry and its potential influence in the transition to a sustainable economy.

In this paper, we do not take a position on what these major owners should do (divest, investor activism, writing off fossil fuel reserves, or nothing at all). We simply map the market structure of equity ownership in the CU200 and identify shareholders who have the greatest potential influence on the corporate governance of these firms. Financial actors continue to invest both debt and equity to propel the fossil fuel industry (Fichtner et al., 2017; Louche et al., 2019); yet, the influence of

financial actors in propping industries attributed to climate instability has largely been ignored (Galaz et al., 2018).

5.2 Finance and Sustainability Transitions

The production of fossil fuels is highly concentrated among a network of large and influential of fossil fuel firms (Ekwurzel et al., 2017). Heede (2014) estimates that just 78 private and government-run carbon majors produced 63 percent of the world's fossil fuels from 1750 to 2010. The production of remaining reserves held by these 78 firms would surpass the remaining global carbon budget by 160 percent (Heede & Oreskes, 2016). Based on updated estimates for our global carbon budget (Matthews et al., 2021), we calculate that the combined 647 gigatonnes of potential emissions held by the CU200 nearly triples the 230 gigatonne carbon budget that remains in order to safely stay within 1.5-degrees of warming. Consequently, the emissions potential of the CU200, examined in this study, is substantial.

Sustainability Transitions in Energy Systems

Actualizing a transition in energy systems is complex but increasingly urgent to mitigate the worst impacts of climate change (Wiseman et al., 2013). Such a transition will require "a combination of technical, organizational, economic, institutional, social-cultural and political changes" (Van Den Bergh et al., 2011, p. 2).

The incumbent regime of carbon-based energy production can be conceptualized as a *socio-technical system* (Markard et al., 2012) consisting of networks of tightly interrelated and dependent actors, social institutions, and technical artifacts. *Socio-technical transitions* can lead to a

fundamental shift in socio-technical systems through a series of technological and non-technical innovation. These innovations have the potential to lead to long-term, multi-dimensional *sustainability transitions* in the form of more sustainable modes of production and consumption. Thus, socio-technical innovations can influence incumbent socio-technical regimes (Loorbach et al., 2017; Westley et al., 2011) and support sustainability transitions.

Socio-technical systems however, face strong path dependencies and lock-ins that favour insufficient and incremental, rather than radical, change (Safarzyńska & van den Bergh, 2010). Theoretically, the multi-level perspective of transitions (Geels, 2002; Geels & Schot, 2007) explains that changes in incumbent *regimes* (such as carbon-based energy production), are embedded within broader social *landscapes* and rivalling socio-technical *niches*. As systems of regimes are slow to change (Berkhout, 2002), innovation is more likely to occur at the 'niche' level (Seyfang & Smith, 2007), which may be driven or facilitated by exogenous 'landscapes' of macroeconomic, political, and cultural trajectories (Burch, 2010; Geels & Schot, 2007). Interactions between regimes, landscapes, and niches can thus play a role in driving socio-technical systems change toward sustainability transitions.

Capital Markets in Sustainability Transitions

Capital markets can be conceptualized as a contextual system that enables finance to flow to niche innovation (Bergek et al., 2015). Unique to capital markets, the system interacts with and overlaps multiple other socio-technical regimes and thus can be seen as the center of innovation in sustainability transitions (Geddes & Schmidt, 2020). Yet, the role of finance and investment as conduits for socio-technical transition remains underrepresented in sustainability transitions literature (Köhler et al., 2019; Savin & van den Bergh, 2021).

More, what literature exists on the role of finance in sustainability transitions to date, has primarily focused on the reallocation of financial capital away from carbon intensive fossil fuels toward low-carbon and renewable alternatives (Bolton & Foxon, 2015; Hafner et al., 2020; Zhang, 2020) or around the effect of financial crises on sustainability transitions (Van Den Bergh, 2013; Van Der Ploeg & Withagen, 2013). However, this constrained view of transitions research overlooks the continued unsustainable developments associated with sizable incumbent investments in the fossil fuel industry (Antal et al., 2020). As clean energy investments stagnate (Zhang, 2020), global investments in fossil fuels have continued to increase since the Paris Agreement, injecting an additional 3.8 trillion dollars into the industry between 2016 to 2020 (Rainforest Action Network, 2021). Consequently, investigating *unsustainable* investments in the fossil fuel industry would benefit transitions research (Antal et al., 2020; Markard et al., 2021).

We take the position that finance is a *resource* necessary for long-term systems change and a *function* of resource mobilization within innovation systems (Bergek et al., 2008; Farla et al., 2012; Hekkert et al., 2007; Karltorp et al., 2017; Naidoo, 2020). Complementary to the multi-level perspective, the innovation systems approach to sustainability transitions analyzes *how* strategies, resources, and capabilities can trigger transformation processes (Farla et al., 2012). As critical context systems (Bergek et al., 2015), research on capital markets will strengthen emerging agendas around the role of finance in impeding or supporting sustainability transitions.

Traditionally, capital markets have remained largely ambivalent in the allocation of financial resources (Wiek & Weber, 2014), financing systems that simultaneously enable and hinder sustainability transitions. Though the allocation of finance as a tangible resource is essential for socio-technical transitions (Farla et al., 2012; Naidoo, 2020), significant resources remain tied to

incumbent regimes. Thus, our research first contributes to this literature by examining the structure of resource allocation in incumbent and unsustainable carbon-based regimes.

Second, though traditionally ambivalent, capital markets now actively engage in innovation trajectories through their influence on resource mobilization, in part due to an increased recognition and response to calls for sustainability. This may come in the form of initiatives to reallocate finance away from incumbent regimes (through divestment, for example), or through initiatives to engage with the incumbent regimes and drive change from within (Edmans, 2014). Consequently, shifting power relations between capital markets and fossil fuels firms strengthen the potential influence of finance in enabling a low-carbon transition (Avelino & Wittmayer, 2016). More, through coordinated engagements (Dimson et al., 2020) capital markets can also function to collectively diffuse intangible knowledge, facilitating the exchange of information and providing incentives for niche innovations within incumbent regimes. Thus, this study analyses the resource mobilization function of capital markets by mapping the network of relations between equity owners and the CU200.

In line with Schumpeter's theory of economic development, innovation in finance through resource allocation and mobilization is a prerequisite for radical economic transitions (Festré & Nasica, 2009; Peneder & Resch, 2015). Finance is a space where the power and influence of asset owners are commodified; however, the way in which this power is exerted to effect change varies (Braun, 2021; Knafo et al., 2013). Niche innovation in sustainability-oriented finance that constrains fossil fuel production will play an important role in a low-carbon transition by reducing the environmental risk and the negative impact of resource use through supply-side constraints that systematically limits the exploration, extraction, or transportation of fossil fuels (Kemp & Pearson, 2007; Ryszawska, 2016). Through this lens, capital markets may be conceived in terms

of networks of actors that may support or hinder transitions, driven by the law of creative destruction (Festré & Nasica, 2009).

Equity Ownership in Fossil Fuel Firms

We assert that capital markets, as a contextual system that influences resource mobilization in innovation systems (Bergek et al., 2015), play a central role in enabling sustainability transitions; however, it is unknown who exactly these key financial actors are in the fossil fuel industry. Thus, the identification of key financial actors that hinder socio-technical transitions is important. Financiers may allocate capital to the fossil fuel industry through a combination of debt and equity financing. Debt financiers can withhold capital from select firms that may not align with the financier's mandate or build incentives into the debt covenants. Equity owners, in contrast, can vote on the future strategic direction and governance of the firm. As equity ownership determines the influence of an investor over future corporate strategy (Appel et al., 2016), equity holders may be most effective in enabling innovation from within the organization. Recent analyses linking equity holdings to climate stability provide tools to directly link financial actors to their contribution of emissions attributed to their investments (Galaz et al., 2018; Naef, 2020). Our paper goes further by looking at the ownership structures of the fossil fuel industry.

Equity markets can exert influence on the fossil fuel industry through one of three mechanisms – exit, voice, and loyalty (Hirschman, 1970). Shareholders show loyalty by holding shares and express discontent by voicing their positions or divesting their holdings. There is a sizable body of literature that has emerged in the past decade on divestment as a means to reduce carbon exposure in a portfolio, depress stock valuation, and limit access to capital (Arbuthnott & Dolter, 2013; Dordi & Weber, 2019b; Henriques & Sadorsky, 2018; Hunt & Weber, 2018; Trinks et al.,

2018). However, the literature on active ownership and climate-related engagement is less established (Bajo et al., 2020; Dimson et al., 2015). Through the lens of agency theory, large owners or collectives can influence corporate governance through active ownership (Fichtner et al., 2017; Gillan & Starks, 2000); however, intervention through active ownership has traditionally been used to increase corporate value, not curtail production as would be needed in the fossil fuel industry. In contrast to the dominant position of agency theory, however, Knafo and Dutta (2020) assert that the historical context of the financialization of the firm was, in fact, a process of corporate empowerment through innovations in shareholder activism that helped reshape the nature of corporate strategy. Within this context, with the heightened risk of asset stranding in the fossil fuel industry and increased commitments to decarbonization, there is a case for radical intervention to mitigate the financial and reputational risks associated with climate change. In practice, the efficacy of engagement varies; while some investors have taken positive steps to engage with the industry, others continue to vote against climate-related shareholder proposals (Martin et al., 2020). Consequently, equity owners that maintain holdings in fossil fuel firms must be held accountable for their continued and unabated contribution to fossil fuel production and, ergo, to climate instability.

5.3 Data and Method

We adopt a network analysis to uncover the structures of ownership in the fossil fuel industry. Data on the 200 most prevalent fossil fuel firms are collected from the CU200. Complementary shareholder data is collected through Bloomberg. To answer the first question on ownership characteristics, the analysis begins with an overarching description of the firms and shareholders in the sample, including the geographical distribution of owners and firms and ownership

distribution by type and size of holdings. To evaluate ownership influence, we present several network models by each type of shareholder and compare the network structures between shareholders. Finally, we conclude with an exposé of the most influential shareholders, based on a novel score calculation.

Data

We rely on two sources of data for firms and owners. Data on fossil fuel firms and their related emissions potential is given by the CU200 database, hosted by Fossil Free Funds. This database provides 100 coal and 100 oil and gas companies with the largest reserves of fossil fuels (Fossil Free Funds, 2020). Collectively, these 200 firms account for 98 percent of proven coal reserves, 98 percent of reported proven gas reserves, and 97 percent of proven oil reserves held by publicly listed companies. Based on the held reserves from Q4 2019, the emissions potential of firms ranges from 106 GT Co2 (Saudi Aramco) to 0.097 GT Co2 (Centennial Resource Development Inc).

Ownership data of these 200 companies is collected from the Bloomberg Terminal[1]. Bloomberg lists owners of most firms and provides a list of owners by the percentage of shares outstanding which they own. One methodological consideration concerns firms with multiple listings (for example, in Hong Kong and Shanghai or London and Amsterdam). For these companies, we adopt the following procedure. In instances where a Chinese firm is traded in both Hong Kong and China,

[1] The 'Bloomberg Terminal' is a computer software, which provides access to real-time financial and investment data, news, and analytics. Among other offerings, Bloomberg provides market and securities information, such as historical share prices, equity ownership, income statements, and balance sheets.

we select the Hong Kong traded stock for greater international access. In instances where a firm has dual listings in the same region, the larger listing (based on market capitalization) is selected. Finally, in instances where a firm has multiple international tickers, the country of registration is selected. Only holdings greater than one percent, as a delineation of material influence, are included in this analysis. Ownership data was collected in February 2021 and reflects the ownership structure at that point in time. Collectively we identified 730 unique shareholders with direct ownership in one or more of the CU200 firms.

Furthermore, shareholders with direct holdings may also have secondary owners that can indirectly influence fossil fuel firms. Thus, for even greater nuance, we include a second layer of (indirect) ownership, where we further identify owners of corporations, holding companies, trusts, venture capital, and shareholders that are listed as other or unclassified. We applied a similar process to identify indirect ownership, by extracting ownership data from Bloomberg for direct owners who may also have shareholders. By examining 'who owns the owners' we can also examine indirect influence, whereby indirect owners may pressure direct owners in favour of alterative, sustainable systems of production.

Some shareholder types such as banks, governments, hedge fund managers, investment advisors, high net worth individuals (HNWI), and sovereign wealth funds were identified as final owners and thus, do not have secondary owners. Consequently, of the 730 direct shareholders extracted from Bloomberg, we investigated a total of 146 direct shareholders and collected ownership data for these firms from Bloomberg in February 2021. Through this process, we identified an additional 188 unique shareholders. Our exploration of indirect owners through the second layer of ownership found that many owners were HNWI. Of the 146 shareholders we investigated for indirect ownership, only 19 percent had additional ownership data. Among the rest, 51 percent had

no additional information listed on Bloomberg (for example, HNWIs), 23 percent were owned by private companies which do generally not disclose ownership, and 6 percent were owned by another CU200 listed firm. We applied the same procedure for managing multiple listings, as delineated in the direct ownership method above for the second layer ownership. We thus conclude with a total of 918 unique shareholders with either direct or indirect holdings in one or more of the CU200 firms.

We note that in some instances, a shareholder may have direct holdings in a firm as well as indirect holdings through another shareholder. For example, Berkshire Hathaway owns 2.52 percent of Chevron, but Vanguard owns 10.11 percent of Berkshire Hathaway and 8.20 percent of Chevron. These ownership dynamics are extrapolated further in the network method and results.

Method

To answer our first research question, on the organizational characteristics of equity owners that invest in the CU200, we begin with a descriptive analysis of spatiality and distribution of firms and shareholders in our sample. By firm, we indicate which firms are included in the sample and some characteristics like the location of headquarters, stock exchange they are traded on, and range of emissions potential. By shareholder, we indicate what types of shareholders are most prevalent, location of headquarters, and proportion of holdings. We next adopt Wojcik et al.'s (2019) typology of economic geography to present the regional distributions between shareholders and the firm. Ownership is delineated into four groups based on the country of registration of the firm and shareholder in relation to the stock exchange. This analysis provides a visual representation of top financial centers based on the location of the shareholder and firm. We briefly speak to the nature of carbon leakage, whereby financiers' export' production capacities to other, less stringent

geographies. We finally conclude the descriptive analysis with a stepwise ownership distribution table (Galaz et al., 2018) that presents how ownership type changes as the proportion of equity ownership rises.

To answer our second research question on the influence of different types of equity owners, we present a collection of "bipartite" (two actor) network models. Simply, bipartite network graphs (Bajo et al., 2020) present a causal relation between two actors. In this study for example, we look at the directed effect of financial actors on fossil fuel firms. Networks are conventionally made of nodes, which represent specific elements (such as a firm or an owner) and of edges, which represent the relationship between elements (such as the size of holding). Thus, networks can be used to present the relationship between fossil fuel firms and specific owners based on the size of their holdings, through visual and quantitative approaches (Rowley, 1997). Notably, social network analyses have been used in the context of stakeholder influence in corporations (Cundill et al., 2018; Giurca & Metz, 2018; Yang et al., 2018) and in sustainability transitions research (Brugger & Henry, 2021; Schanz et al., 2019).

Networks can provide quantitative insights through centrality metrics, which are used to measure the relative importance of a node (a shareholder of a firm) within the graph. The metrics can inform, for example, how influential a shareholder is in the network or how influenceable a fossil fuel firm may be. We calculate two centrality measures, degree centrality and betweenness centrality, due to their efficacy in addressing the research question (Das et al., 2018).

Degree centrality (Equation 1) is simply the number of nodes that a focal node is connected to. In this study, degree centrality can be thought of as the number of equity owners a (focal) fossil fuel firm may have or the number of fossil fuel firms a (focal) equity owner invests in. Owners with higher degree centrality scores may have greater influence in the network through their holdings

in multiple firms. However, this measure of degree centrality assumes all edges are equal; a holding of one percent and fifty percent would be weighed the same.

$$Equation\ 1: C_D(v) = \deg(v)$$

The second, weighted betweenness centrality (Equation 2) assesses the degree to which a focal node (v) lies on the shortest path (σ) between two other nodes (s and t). In social networks, focal nodes that lie between two nodes act as important bridges that connect many nodes in the network, and thus, can assert control over the flow of information and have greater influence on the network. The shortest path (σ) is found identified based on 1) the number of intermediary nodes and 2) the strength of the ties between nodes, namely the size of a holding. Thus, the weighted betweenness centrality is presented as a complementary score, as a measure of the flow of information and influence within the network. Other centrality measures like closeness centrality were not included in this analysis, as they prove to be less effective for disconnected networks.

$$Equation\ 2: C_{B(v)} = \sum_{\{s \neq v \neq t \in V\}} \frac{\sigma_{st}(v)}{\sigma_{st}}$$

Our analysis further extrapolates how centrality differs between shareholder types by comparing degree and betweenness measures between public shareholders (governments and sovereign wealth funds), corporations, investment advisors, banks, pension funds, and high net worth individuals. We compare these scores against a benchmark of the complete network. This informs us about the potential influence each shareholder type may have within a network. For example, investment advisors with many small holdings in multiple firms may adopt a different engagement strategy than governments with large holdings in one or few firms.

Finally, to answer the last research question, which individual shareholders have the greatest potential impact on the governance of fossil fuel firms, we conclude with an exposé of the most influential owners, using a combination of their degree measure and the proportion of emissions held within the sample (Equation 3). The calculation is comprised of two parts. First, we sum the proportion of emissions potential a shareholder (*j*) holds in a fossil fuel firm (*i*) across all firms. In and of itself, this metric has some limitations. First, firms may have multiple listings with different holders. Thus, we do not infer that any one shareholder 'owns' an exact proportion of a firm's potential emissions. Second, the emissions calculation does not incorporate the shareholders' ability to influence the industry. Thus, the held emissions are multiplied by a degree score, which is calculated from the preceding network models. The degree score is chosen for this equation because the size of holding is incorporated into the left-hand side of the equation and thus, the weighted centrality score would double count that effect. Firms with more connections receive a higher score for their ability to influence numerous firms and, consequently, the industry as a whole. This calculation allows for us to rank equity owners without allocating specific emissions amounts.

$$Equation\ 3: Score_j = \sum (Emissions\ Potential_i \times Percent\ Holding_i) \times \frac{Degree_j}{\max_j Degree_j}$$

Limitations

We highlight some methodological limitations to the data collection and analysis. First, the method does not capture all owners with holdings in the firm. Bloomberg and similar data repositories such as Orbis only publish ownership data for shareholders with holdings greater than 0.01 percent. Moreover, a firm may have multiple publicly traded listings, which are not captured in this method.

For replicability, we select only one listing per firm, based first on the country of registration (traded on a stock exchange in the country where the firm is registered) and second on the market capitalization of the listing in instances where multiple listing share a common region. Third, this study examines only one additional layer of indirect ownership for select types of owners that we deem not to be final owners. Additional layers of indirect ownership could be conducted; however, we believe this would not add significant insight. Fourth, we acknowledge that we may not have perfect ownership data for all companies, as ownership data may be reported at different times. Though large holdings do not change substantially, this is pertinent as investors shift their investments through divestment or decarbonization efforts. We address this limitation by collecting all ownership data at a single point in time, in February 2021. Fifth, ownership data of some firms on the CU200 are not available. Our data collection for ownership data found valid useable data for 182 of the 200 CU200 companies. This discrepancy arises from 13 firms that do not provide holders greater than one percent, four firms that are listed on both the top 100 coal and top 100 oil and gas list, and one that could not be identified (Encana, now Ovintiv). Lastly, due to limitations around exact ownership holdings, we do not allocate specific quantities of emissions potential to any one shareholder; we simply rank shareholders based on the availability of data. We recognize that ownership data does not allow us to estimate the totality of ownership in a company and acknowledge the owner may also hold more emissions in investments outside of the CU200 companies.

5.4 Results

Ownership Characteristics

We identify 918 distinct (direct and indirect) shareholders with greater than 1% ownership in at least one of the fossil fuel firms in our sample. To answer research question one, what are the organizational characteristics of equity owners, we present a descriptive analysis of the distribution of actors in our sample, by region, type, and size of holding.

By region, 60 firms on the CU200 are registered in the United States, followed by China, Canada, Russia, Australia, and India. These firms may trade on a different stock exchange than the country in which they are registered. By stock exchange, 61 companies are traded on a United States stock exchange, followed by China, Canada, Australia, Hong Kong, and Russia. In contrast, ownership distribution is skewed toward the United States, with 213 of the 918 owners based out of the United States. Table 5-1 below presents the top firms, stock exchanges, and owners by region.

Table 5-1 Regional Distribution of Firm, Stock Exchange, and Owner

CU200 firm Distribution by Region		**CU200 firm Distribution by Stock Exchange**		**Owner Distribution by Region**	
United States	60	United States	61	United States	213
China	23	China	19	China	73
Canada	17	Canada	16	Japan	60
Russia	13	Australia	13	India	59
Australia	12	Hong Kong	13	United Kingdom	36
India	10	Russia	12	Canada	30

The regional distribution table presents the top countries in the sample based on the headquarters of firms in the Carbon Underground 200 (CU200), the stock exchanges in which the firms are traded, and the registered location of the equity owner.

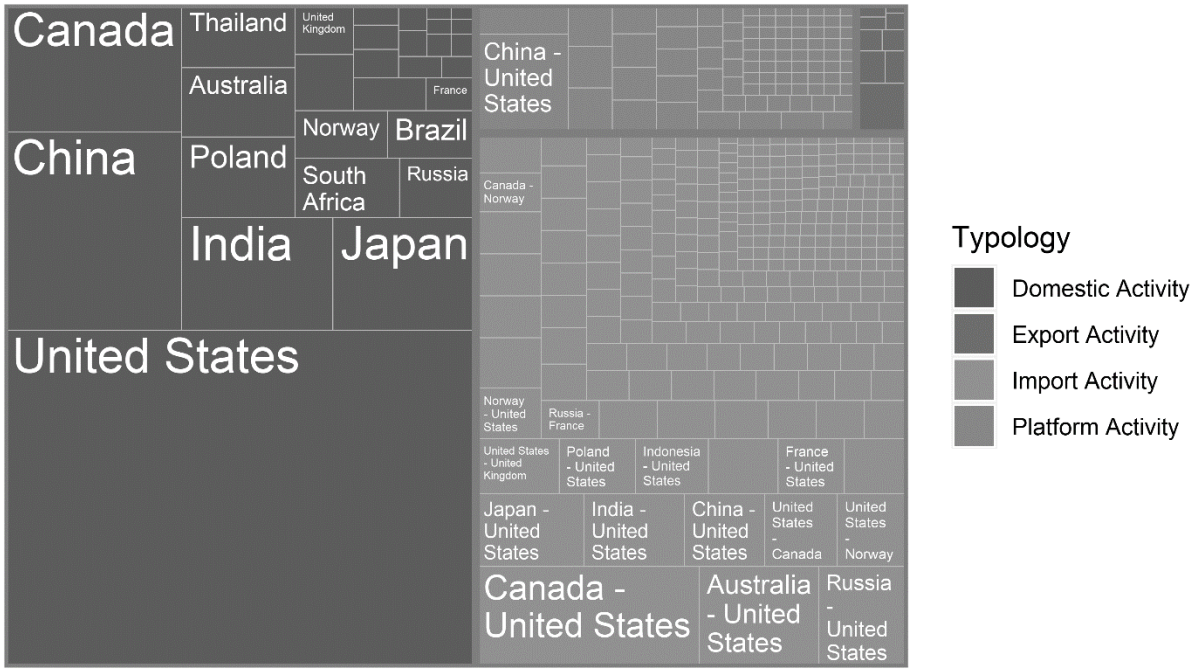
To understand the spatial relations between owners and firms, we adopt Wojcik's (2019) typology to present four groupings, based on the country of registration of the firm and shareholder in relation to the stock exchange. If, for example, a Canadian shareholder owns equity in a Canadian fossil fuel firm, which is traded on a Canadian exchange, this constitutes a *domestic* activity. In

contrast, if an American firm owns equity of a Canadian fossil fuel firm traded on a Canadian exchange, this constitutes an *import* activity. Further, an *export* activity is delineated as a domestic (i.e. American) shareholder, with holdings in a foreign (i.e. Chinese) firm, traded on a domestic (i.e. American) stock exchange. Finally, a *platform* activity is delineated as a foreign (i.e. American) shareholder, with holdings in a foreign (i.e. Chinese) firm, traded on a foreign (i.e. Hong Kong) stock exchange. This typology is presented in Figure 5-1 below, which visually presents the frequency of instances that a shareholder and firm fit in each grouping. Excluding firms and shareholders with unclassified locations, 1,709 holdings (52.2 percent) are classified as domestic activities. 51.3 percent of those holdings are within the United States. This result suggests that sizable power to reduce emissions resides in the domestic activity base and countries like the United States, Canada, China, and Japan should be leading decarbonization efforts domestically. Indeed, there is evidence that investors are more likely to engage and succeed in engagement efforts when the target firm is domestic (Dimson et al., 2020). By import activity, American shareholders are seen to invest frequently in Canadian, Australian, Russian, Japanese, Indian, and Chinese fossil fuel firms. By platform activity, American shareholders often invest in Chinese fossil fuel firms on foreign exchanges, such as the Hong Kong stock exchange. Finally, export activities, whereby a domestic shareholder holds domestically traded shares in a foreign firm, are less common. This visualization highlights the fact that wealthy nations, such as the United States, are investing in pollution abroad, which ties closely with the carbon leakage concept.

The exportation of carbon emissions by oil-exporting nations is an active point of discourse in climate policy literature (Khan et al., 2020). Through international trade, exports of fossil fuel resources offset national consumption-based carbon emissions in oil-producing nations while profiting off the production of carbon resources. Literature on carbon leakage attests that global

trade of resources transfer pollution to other countries with less stringent climate policy, while wealthy economies gain from production without the associated emissions (Hasanov et al., 2018; Liddle, 2018). The spatial aspects of capital and carbon leakage remain relatively underdeveloped (Liu et al., 2018). Through cross-border investment activity, shareholders can prop and profit off fossil fuel production and emissions outside of federal jurisdiction.

Figure 5-1 Geographic distribution of shareholders and firms



A typology of ownership activities based on the nationality of firms and shareholders. Regional data for firms is exported from the Carbon Underground 200 database. Regional data of equity owners and stock exchange is exported from the Bloomberg Database. A firm or shareholder is classified as domestic if they share the same region as the stock exchange, and foreign if the firm or shareholders' nationality differs from the stock exchange. Domestic activity is delineated as a domestic shareholder, with holdings in a domestic firm. Import activity is delineated as a foreign shareholder, with holdings in a domestic firm. Export activity is delineated as a domestic shareholder, with holdings in a foreign firm. Platform activity is delineated as a foreign shareholder, with holdings in a foreign firm.

Second, we present the average size of holdings by ownership type. Results on Table 5-2 and Figure 5-2 indicate that small holdings (greater than 1 percent) are mostly held by investment advisors (53.8 percent). That is not to say investment advisors cannot influence the firm; at 5 percent (typically denoted as block holding), investment advisors still comprise 48 percent of

owners. At lower concentrations of ownership, investment advisors may affect change through proxy voting and through coordinated engagements (Dimson et al., 2020).

In contrast, owners with greater than 20 percent holding in any one firm (denoted as a minority interest shareholder), are largely comprised of governments and corporations, who collectively account for 64.3 percent of owners. At the 50 percent mark (denoted as majority shareholders) – owners that hold over half of equity holdings in a firm – governments account for 53.5 percent of owners. 23 of the 195 fossil fuel firms in our sample have a government entity as the controlling shareholder. At these higher concentrations of ownership, governments are at the forefront of effecting change. Notable examples of shareholders include the Kingdom of Saudi Arabia, the Government of India, and State-Owned Enterprises of China. In these instances, the role of governments is not simply to create enabling conditions, but to actively disrupt the status quo (Naidoo, 2020). However, the influence of these major shareholders is concentrated within specific firms and not the industry as a whole.

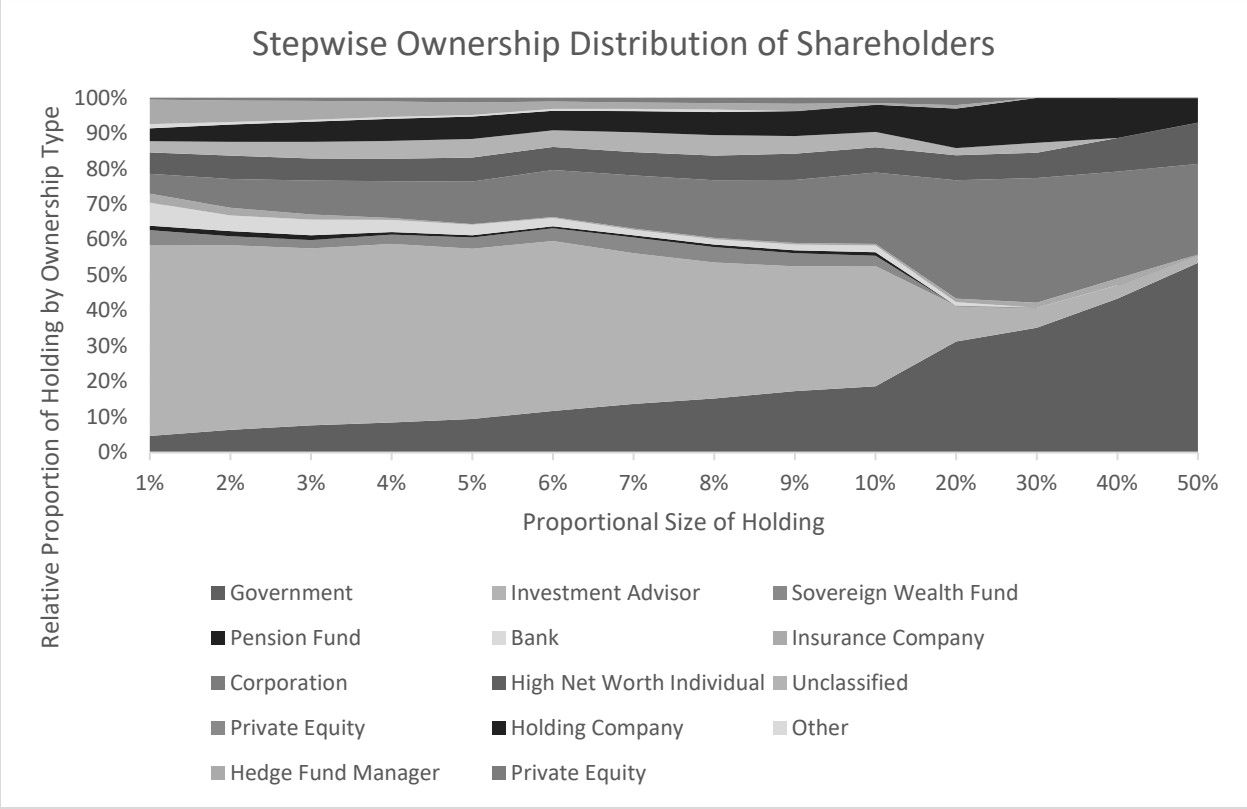
Table 5-2 Stepwise Reduction in Ownership by Shareholder Type

Size of Holding	***Government***	***Investment Advisor***	***Sovereign Wealth Fund***	***Pension Fund***	***Bank***	***Insurance Company***	***Corporation***	***High Net Worth Individual***	***Unclassified***	***Private Equity***	***Holding Company***	***Other***	***Hedge Fund Manager***	***Private Equity***	**Total Owners**
1%	80	923	74	21	112	43	97	103	54	1	62	20	119	8	1717
2%	63	515	25	14	44	21	80	65	38	1	48	7	60	7	988
3%	54	351	16	10	31	10	67	44	33	0	40	4	37	6	703
4%	49	290	15	4	20	3	60	36	29	0	36	3	25	6	576
5%	45	228	15	3	14	1	57	32	25	0	30	2	17	6	475
6%	45	184	14	2	9	1	51	25	18	0	21	2	8	4	384
7%	44	136	14	2	5	1	48	21	18	0	19	2	6	4	320
8%	42	106	12	2	4	1	45	19	16	0	18	2	5	4	276
9%	42	85	9	2	4	1	43	18	12	0	17	0	5	4	242

10 %	39	71	6	2	4	1	42	15	9	0	16	0	1	3	209
20 %	31	10	0	0	1	1	33	7	2	0	11	0	1	2	99
30 %	25	4	0	0	0	1	25	5	2	0	9	0	0	0	71
40 %	23	2	0	0	0	1	16	5	0	0	6	0	0	0	53
50 %	23	1	0	0	0	0	11	5	0	0	3	0	0	0	43

The stepwise reduction table presents the number of owners by shareholder type that have at least a certain percent of ownership in the CU200. We delineate owners with greater than 5 percent as block holders, owners with greater than 20 percent as minority shareholders, and owners with greater than 50 percent as majority shareholders.

Figure 5-2 Stepwise Reduction in Ownership by Shareholder Type



Stacked area chart depicting the relative concentration of owners by share of total ownership by each type of investor. Ownership data is exported from the Bloomberg database. The X-axis depicts the proportional size of holding by a shareholder. The Y-axis depicts the relative proportion of holding by ownership type. Under 10 percent, investment advisors are most prevalent. Above 50 percent, governments are most prevalent.

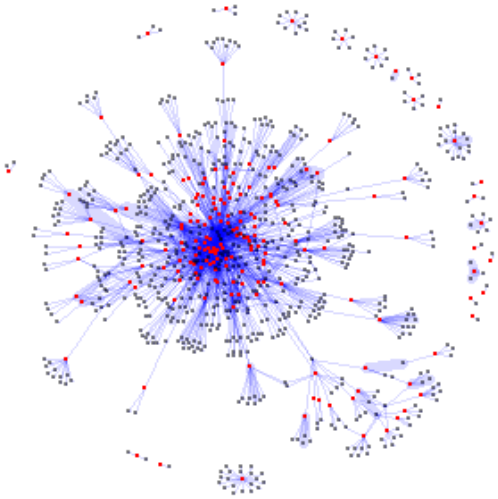
Network Analysis

Second, in relation to the influence of capital markets on resource mobilization, we present a network analysis of ownership and influence by ownership types. The structure of the graph, based on the edges and nodes, visually depicts the influence shareholders may have in enabling sustainability transitions within the CU200. Figure 5-3 below depicts the complete ownership network, comprised of 913 nodes (dots) and 1,691 edges (lines). Fossil fuel firms are denoted as red dots, while shareholders are denoted as black dots.

Several inferences can be made from the visualization. First, the disconnected networks, that is, smaller network graphs that are not connected with the larger network graph, visualize instances where a fossil fuel firm is held by an owner that does not hold shares in any of the other CU200 firms. For instance, the Kingdom of Saudi Arabia has a majority holding in Saudi Aramco but does not have measurable shares in any other CU200 firm. In such instances, shareholders may be able to influence the governance of one firm but not the industry as a whole. In other instances, a firm may have one large shareholder as well as several smaller shareholders. Yanzhou Coal Mining, for example, has one minority interest shareholder – a Chinese government entity with 23.95 percent ownership – but is also held by BNP Paribas, Blackrock, Vanguard, and Dimensional Fund. A two-tier engagement strategy that combines a lead shareholder with supporting shareholders may be effective in influencing such firms (Dimson et al., 2020). Finally, to the center of the connected network are firms that are more broadly and equally held by many investors with smaller ownership stakes. Here, we see firms like BP, Chevron, and Royal Dutch Shell, who have several shared owners and no one shareholder with greater than 10 percent ownership. For such firms, coordinated engagement efforts by shareholders may be effective in not only influencing

the firm, but the industry as a whole. Consequently, firms along the edges of the network compared to those to the center will warrant different forms of intervention (Kanger et al., 2020).

Figure 5-3 Direct Ownership Network

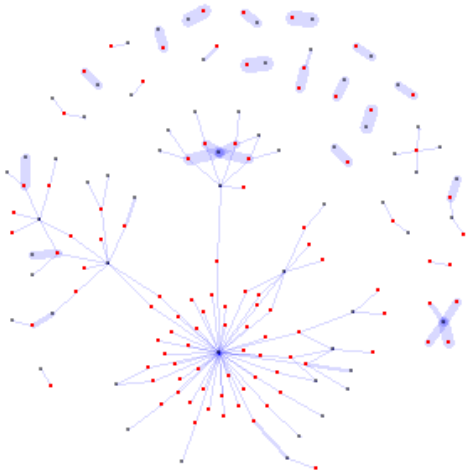


Network model of the direct and indirect shareholders with greater than 1 percent ownership in the Carbon Underground 200. Red nodes represent fossil fuel companies. Black nodes represent shareholders. The thickness of the blue edge between nodes represents the relative size of holding.

We extrapolate further that network structures vary considerably across shareholder types. We presented in section 4.1.2 that investment advisors may have more numerous but smaller holdings in multiple firms, while governments may have large holdings in a few firms. Our network subgraphs by shareholder type, presented in Figure 5-4 below, corroborate this finding across six groupings of shareholders. In addition to the network graph, we highlight some nodes of interest based on the degree of holders and firms.

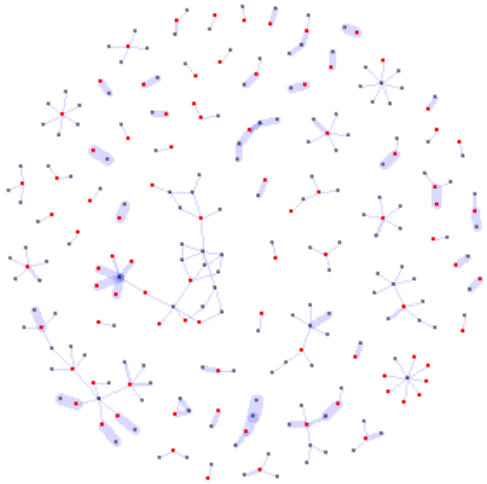
Figure 5-4 Ownership Networks by Shareholder Type

a) Public (Government + Sovereign Wealth Fund)



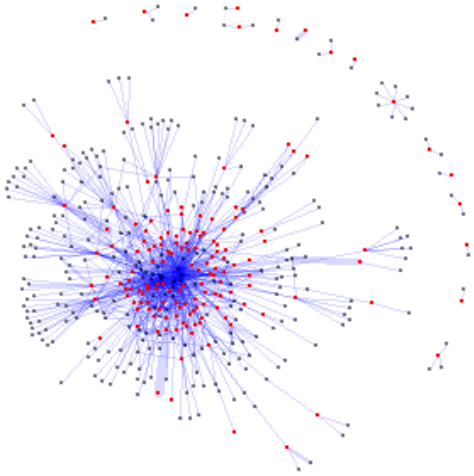
Top Holder(s): Norges Bank (46)
Top firm (s): Bayan Resources, Eni, NLC India, Oil India, ONGC, Shanxi Coking (4)

b) Corporation (Corporation + Holding Company)



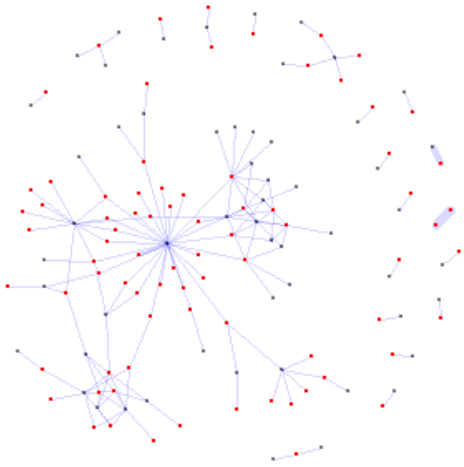
Top holder (s): Power Corp of Canada (7)
Top firm (s): Nava Bharat Ventures, SACYR SA (6)

c) Investor (Investment Advisor + Hedge Fund Manager + Private Equity)



Top Holder(s): Vanguard Group (106)
Top Firm(s): Arch Coal (29)

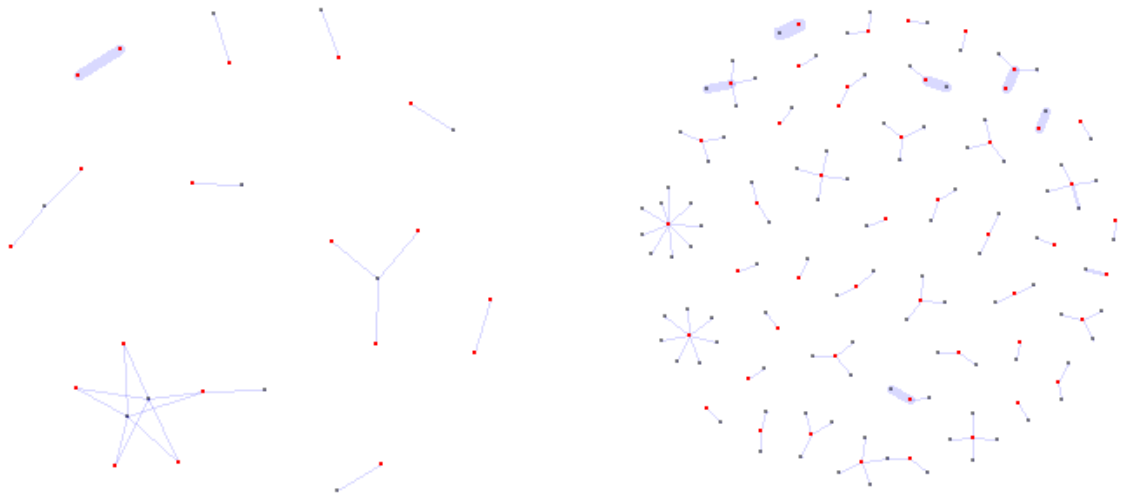
d) Bank (Bank + Insurance Company)



Top holder (s): Bank of New York Mellon (28)
Top firm (s): Itochu (10)

e) Pension Fund

f) High Net Worth Individuals



Top Holder(s): Nationale-Nederlande (5), Powszechny Zakład Ubezpieczeń Spółka Akcyjna (PZU) (5)
Top Firm(s): PGE (3)

Top holder (s): Todd Thomas (2)
Top firm (s): Nava Bharat Ventures (9)

Network model of the direct and indirect shareholders with greater than 1 percent ownership in the Carbon Underground 200, split by shareholder type. Subgraphs are presented for public shareholders, corporations, investors, banks, pension funds, and high net worth individuals. Red nodes represent fossil fuel companies. Black nodes represent shareholders. The thickness of the blue edge between nodes represents the relative size of holding. The top shareholder and top firm, based on the number of edges, is also presented under each subgraph.

Finally, we present the centrality measures for the subnetworks, to qualitatively compare the potential influence of different stakeholder types (Table 5-3). First, some subgraphs (like public, corporation, pension fund, and HNWI) have fewer edges than nodes. This infers that, on average, nodes in those networks have fewer than two edges. Saudi Aramco, for example, only has one edge connected to the Kingdom of Saudi Arabia. This relation is confirmed in the degree centrality measure, with all four subsample network graphs having a degree centrality score of under 2. Conversely, the investor subsample graph (panel c in figure 5-4) has a higher degree centrality than both the complete direct and indirect network, inferring that investors in this subsample have holdings in many firms. The higher betweenness score also indicates that these shareholders play an important informational role in those networks and may consequently sources of knowledge diffusion within the network.

Table 5-3 Network Dynamics by Shareholder Type

Network Model	Nodes	Edges	Degree	Betweenness
Direct Network	913	1,691	3.73	1236.85
Indirect Network	1,098	2,097	3.81	1634.39
Public	159	149	1.87	109.54
Corporation	255	202	1.58	8.13
Investor	454	1042	4.59	475.36
Bank	135	153	2.27	83.38
Pension Fund	29	23	1.59	0.86
HNWI	149	104	1.40	0.95

The network statistics depict the number of nodes and edges within each subsample network as well as the average degree centrality (Equation 1) and betweenness centrality (Equation 2) of each network. The direct network includes direct ownership in the CU200. The indirect network includes second order ownership. Subsample networks are presented by shareholder type.

Influential Shareholders

Finally, in response to our third research question, we examine which owners have the greatest influence on the network and thus, have the potential to enable a low-carbon transition within the CU200. We rank the most influential shareholders in Table 5-4, based on their centrality in the network, the aggregate size of their holdings across all firms, and the proportion of potential emissions associated with those holdings.

Ten of the top 20 owners are investment advisors like Blackrock, Vanguard, and State Street. Generally, investment advisors have a higher degree score (indicating that they are more central to the network through their numerous holdings) but lower cumulative emissions. Sovereign Wealth Funds (Norges Bank and China Investment Corporation) and banks (Bank of New York Mellon) similarly have higher degree measures but lower emission measures. Governments in contrast, often have few but large holdings in the CU200. Consequently, their emissions measures are high, but their degree measures are low. Ten of the top 20 owners are also located in the United States, nine of which are investment advisors.

Furthermore, the top ten owners (Blackrock, Vanguard, the Government of India, State Street, the Kingdom of Saudi Arabia, Dimensional Fund Advisors, Life insurance Corporation, Norges Bank, Fidelity Investments, and Capital Group) have notable influence over the trajectory of the fossil fuel industry. Collectively, these ten shareholders own 49.5 percent of the emissions potential from the CU200 (the left side of equation 3). The top ten are also more central to the network, with an average degree centrality of 43.9 compared to 2.4 across the remainder of the shareholders (the right side of equation 3). This indicates that not only do these ten shareholders account for a sizable share of emissions potential, they also have immense potential influence in enabling sustainability transitions among the CU200 and, more broadly, the incumbent carbon-based energy regime.

Table 5-4 Top Influential Shareholders in the CU200

Target	Type	Country	Degree	Emissions	Score
Blackrock	Investment Advisor	United States	0.97	10.14	9.85
Vanguard Group	Investment Advisor	United States	1.00	8.86	8.86
Government of India	Government	India	0.04	68.23	2.57
State Street Corp	Investment Advisor	United States	0.45	2.25	1.02
Kingdom of Saudi Arabia	Government	Saudi Arabia	0.01	104.21	0.98
Dimensional Fund Advisors	Investment Advisor	United States	0.43	1.94	0.84
Life Insurance Corporation	Government	India	0.06	11.60	0.66
Norges Bank	Sovereign Wealth Fund	Norway	0.54	1.14	0.61
Fidelity Investments	Investment Advisor	United States	0.41	1.46	0.59
Capital Group Company	Investment Advisor	United States	0.24	1.99	0.47
Bank of New York Mellon	Bank	United States	0.26	1.44	0.38
JPMorgan Chase & Co.	Investment Advisor	United States	0.34	0.76	0.26
Russian Federation	Government	Russia	0.01	19.38	0.18
Shaanxi Coal & Chemical	Government	China	0.01	17.57	0.17
Adani, Gautam S.	High Net Worth Individual	India	0.01	15.65	0.15
Citigroup Inc.	Investment Advisor	United States	0.05	3.10	0.15
HDFC Asset Management	Investment Advisor	India	0.04	3.93	0.15
China Investment Corporation	Sovereign Wealth Fund	China	0.08	1.65	0.14
Geode Capital Management	Investment Advisor	United States	0.28	0.50	0.14

The top influential shareholders are measured using a combination of their degree measure and the proportion of emissions held within the sample. The top 20 influential shareholders are presented based on their score as presented in Equation 3. Degree and Emissions values are included for the reader to distinguish which factor has greater influence on the final score.

5.5 Discussion

This study identified the structures of equity ownership in the CU200, the leading fossil fuels firms with the greatest potential (by carbon reserves) to contribute to anthropogenic climate instability. Acknowledging potential emissions held by the CU200 would overshoot the global carbon budget three times over, production must be curtailed to keep warming under a safe threshold. We posit that capital markets, through their influence on the functions of resource mobilization, have the potential to disrupt incumbent regimes and create enabling conditions for sustainability transitions. Given recent pledges to reduce their carbon exposure in line with net zero targets, capital markets have the potential to shift from a contextual system that hinders a socio-technical transitions to one that could drive the emergence of more sustainable, low-carbon systems of production.

Revisiting our research questions, we first asked, what are the organizational characteristics of equity owners that invest in the CU200? Investment advisors are the most prevalent type of owners by number of holdings, however, governments and similar owners may have greater influence through larger holdings. Potential for systemic interventions (Seyfang et al., 2010) resides in the domestic activity base, and consequently, countries like America, Canada, China, and Japan should lead decarbonization efforts at home. Second, we asked, through functions of resource mobilization, how much influence do different types of equity owners have over the governance of the CU200? Centrality measures indicate that some owners smaller owners may benefit from coalition building and coordinated engagement to exert greater influence across the industry (Dimson et al., 2020) that is needed for a systemic transition. In two-tier structures with larger and smaller owners, power may shift to activist shareholders who subsequently seek the support of more influential owners (Braun, 2021). Third, to identify potential enablers of socio-technical innovation, we asked, which individual shareholders have the greatest potential impact on the

governance of fossil fuel firms. Our study found that the ten investors with the most influence on the future use of fossil fuel reserves are investment managers (Blackrock, Vanguard, State Street, Dimensional, Life insurance Corp, FMR and Capital Group) as well as Government and state-owned entities (India, Saudi Arabia and Norway). These ten actors have the greatest potential impact on the future usage of most of the world's carbon reserves, based on the number and size of ownership and the related emissions potential of the firms. We conclude that the decisions by these financial actors, through their holdings in the CU200, have the potential to drive a low-carbon transition.

Our results corroborate the positions of Fichtner et al. (2017), Gillan and Starks (2000), and Dimson et al. (2020), who state that equity owners can influence corporate governance through active ownership. By examining equity ownership in the CU200, this study is the first of its kind to examine equity ownership through the lens of future-looking supply-side solutions. By exposing the most prominent shareholders in the sphere, we raise a call to action, to align their holdings with a low-carbon transition, or to be held accountable for propagating climate instability.

Relating to the literature, we offer several pragmatic insights into capital markets and sustainability transitions. First, we address a notable gap in sustainability transitions research on the impact of *existing* fossil fuel investments. While literature often focuses on the reallocation of capital to low-carbon alternatives, investments in fossil fuels have continued to grow as renewable investments have stagnated (Zhang, 2020). In line with Antal et al. (2020), sustainability transitions research can benefit from examining such unsustainable developments to understand how existing capital allocation can accelerate or undermine sustainability transitions.

Second, the research contributes to the technological innovation systems literature, framing capital markets as critical contextual systems that influence the functions of resource mobilization

(Bergek et al., 2015). The networks presented in this study highlight the interconnections between two key actors (capital markets and fossil fuel firms) in sustainability transitions and exemplifies how equity owners can enable sustainability transitions. The results also highlight that not all owners are equal, and thus, channels of influence differ between actors. Large (majority) shareholders like governments and high net worth individuals have significant influence on the governance of few fossil fuel firms. Conversely, smaller (blockholder) shareholders, through coordinated engagement, can collectively leverage resources to drive systemic change across the industry.

Third, appropriate policy interventions are needed to shape the directionality of socio-technical innovation in capital markets and the fossil fuel industry (Andersson et al., 2021; Kanger et al., 2020; Nykvist & Maltais, 2022; Polzin et al., 2016; K. M. Weber & Rohracher, 2012). Voluntary commitments and policy interventions may lead to radical innovation in capital allocation processes through the process of creative destruction. Certainly, with increasingly ambitious commitments by groups like the Task Force for Climate Related Financial Disclosure and the Glasgow Financial Alliance for Net Zero, to achieve net-zero targets, equity owners will likely increase pressure on firms to decarbonize their economic activities. More, with increased awareness of the risks of stranded assets (O. Weber et al., 2020), capital markets may be incentivized to enable rather than hinder sustainability transitions. Yet, while voluntary commitments are on the rise, policy interventions may still be required to transcend the path-dependent inertia of capital markets that stifle radical innovation. Adequate policy interventions can simulate equity owners in the CU200 to meaningfully engage with the industry in a manner that restricts emissions and mitigates climate-related financial risks.

Finally, this paper makes a notable methodological contribution regarding the power financial markets wield, as evidenced by the data and results. The results not only assert that financial markets can influence the trajectory of sustainability transitions as enablers for socio-technical transitions (Fischer & Newig, 2016), but also exemplify that power is concentrated among just a handful of powerful and path-dependent financiers. We reiterate that reduction of emissions exposure without reductions in production is simply not enough to mitigate the climate crisis. Thus, we put forth a call for sustainable finance scholars to give even greater merit to research on how financial actors contribute to climate instability and their role in enabling sustainability transitions. This paper introduces network analysis as a robust method of analyzing ownership dynamics and can be extended for a deeper examination. Future research utilizing network models and the proposed novel ranking criteria may be replicated in carbon-intensive sectors like steel, cement, and transport, as well as in the renewables sector and in industries that contribute to biodiversity loss, such as agriculture, fishing, and logging. We maintain that financing that perpetuates carbon emissions and hinders sustainability transitions should be held responsible for the climate instability caused by those emissions.

The global commitment to climate action requires grand-scale responses, and grand-scale responses require finance (Naidoo, 2020). Sustainability transitions will struggle to materialize without the active engagement of financial actors that perpetuate the exploration, extraction, and transportation of fossil fuels and perpetuate the economic activities that contribute to climate instability. Consequently, greater emphasis must be placed on understanding ongoing unsustainable trends in finance in order for transitions studies to help society move in the direction of sustainability (Köhler et al., 2019).

In response to our overarching research question, who owns the CU200, our study asserts that a low-carbon sustainability transition can be championed by a relatively small group of influential shareholders. These actors have the potential to influence major fossil fuel companies by constraining access to financial capital or by influencing corporate strategy through active ownership. However, the financial system may be unlikely to sustain the transformative changes that are necessary to respond to the climate crisis unless it is disciplined to do so (Naidoo, 2020). Consequently, future research on how capital markets hinder or enable socio-technical transitions through incumbent and unsustainable investments in fossil fuels is critically required to hold financiers responsible for sustaining or restricting economic activities that coordinate or stall transformative processes.

6. CONCLUSION

Climate change poses an existential threat to humankind. Fossil fuel production and combustion have directly contributed to the great acceleration and global prosperity (Smil, 2000); yet it is now the leading cause of anthropogenic global warming (Hansen et al., 2008; Heede & Oreskes, 2016; Quéré et al., 2013). To mitigate the worst impacts of climate change, the vast majority of existing fossil fuel reserves must remain in the ground (M. R. Allen et al., 2009; Friedlingstein et al., 2022; Matthews et al., 2021; Meinshausen et al., 2009). This is not a technical challenge but a profoundly political and cultural one.

The confluence of rising production costs, clean energy innovation, and the urgency for climate action now compel countries around the world to enact a low-carbon energy transition driven by a socially imposed limit to carbon production (Jaccard et al., 2018). Though critical for climate stability, such a transition could result in disruptive adjustments in carbon-intensive sectors, with significant consequences for economic stability (Campiglio et al., 2018; Geels et al., 2017). For example, existing oil, gas, and coal reserves must remain in the ground in a carbon-constrained future (Matthews et al., 2021), resulting in stranded assets - which not only result in economic losses across multiple carbon-intensive sectors (O. Weber et al., 2020) but could also trigger cascading losses throughout interconnected financial systems, resulting in a global financial crisis (Cahen-Fourot et al., 2019; Campiglio et al., 2018).

The call for action is ambitious but feasible with concerted action. Capital markets, through their function of resource mobilization, may be particularly influential in enabling a low-carbon transition (Bergek et al., 2008; Hekkert et al., 2007; Polzin et al., 2016). Equity owners, as the focus of this study, can influence organizations through engagement or divestment (Appel et al., 2016; Dimson et al., 2015). More, with the heightened risk of asset stranding and increased

commitments to decarbonization, there is a case for radical intervention to mitigate the financial and reputational risks associated with climate change. Capital markets thus have a vested interest in both economic and climate stability (Hawley & Williams, 2000).

However, there remains a gap in academic research on how financial actors can enable a low-carbon transition within the fossil fuel industry. Extending on seminal works by (among others) Gillan and Starks (2000), Galaz et al., (2018), Carroll and Huijzer (2018), Bajo et al., (2020) and Dimson et al., (2020), this research makes a notable contribution to the growing study of equity ownership dynamics in carbon-intensive industries. It is the first collection of studies that uniquely focus on shareholders' influence in enabling a low-carbon transition in the fossil fuel industry.

6.1 Contribution to Knowledge

This dissertation makes several novel contributions to the literature on sustainability management and on capital market interventions for climate action.

First, we establish that the field of sustainability management, through its ontological and process-oriented focus, is better suited to address grand societal challenges like climate change (Dordi & Palaschuk, 2022). We assert that fixation on isomorphic theories constrains sustainability management research and inhibits operational outcomes required to drive grounded action on grand challenges. Thus, we present critiques of conventional management theories like agency theory and engage with theories from political science and sustainability transitions literature to inform this dissertation. In doing so, we contribute to a timely academic discourse (Linnenluecke & Griffiths, 2013; Starik & Kanashiro, 2013; Williams et al., 2017), attempting to delineate whether sustainability management should be a distinct field of study in management research.

Outlining the strengths and shortcomings of sustainability management efforts to date, our review is designed to leave management scholars better equipped and potentially more motivated to meaningfully integrate sustainability as a guiding principle for conducting problem-oriented impact-focused research on grand challenges.

Second, we contribute to a growing body of literature on supply-side interventions for climate action (Erickson et al., 2018; Green & Denniss, 2018; Kemp & Van Lente, 2011; Lazarus & van Asselt, 2018; Piggot et al., 2018). Research and practice on the efficacy of supply-side carbon constraints for energy transitions remain nascent (Le Billon & Kristoffersen, 2019) - and although there is evidence that both state and non-state actors can lead interventions, the role of capital markets in constraining carbon emissions in the fossil fuel industry remains unexplored. By identifying influential shareholders in the fossil fuel industry, our research asserts that incumbent financial actors can enable a low-carbon transition by enacting supply-side constraints that systematically limit the exploration, extraction, or transportation of fossil fuels (Kemp & Pearson, 2007; Ryszawska, 2016). We highlight that capital markets have begun to respond to the low-carbon transition, reallocating capital toward emissions reduction solutions through, for example, reducing the carbon exposure of their portfolio through divestment or investing in renewable energy, energy efficiency, and low-carbon alternatives (Strauch et al., 2020). However, reduction of carbon exposure without reduction in emissions is simply not enough to mitigate the climate crisis (Steffen et al., 2018). Sustainability transitions will struggle to materialize without the active engagement of financial systems that shift the economic activity of fossil fuel firms toward sustainability (Naidoo, 2020).

Third, we make a novel contribution to research methods for sustainability. Novel methodological approaches utilizing advancements in big data, text analysis, and social network modelling are

nascent but rapidly evolving in management literature. Though slower to appear in sustainability literature, the recent proliferation of systematic literature reviews that utilize bibliometrics, natural language processing, topic modelling, and research mapping (Bansal, Gualandris, et al., 2020; Linnenluecke et al., 2020) is reinvigorating the means by which research examines large swaths of unstructured texts. Indeed, chapters two and three both exemplify the applications of these novel computational methods, unlocking insights into latent axiomatic characteristics that delineate complementary fields of study. We anticipate that the democratization of open-source data and analytics alongside increased text data availability will inevitably accelerate this trend over the next decade. Relatedly, network modelling has several relevant uses in both sustainability transitions and sustainability management research. First, in socio-technical systems research (Markard et al., 2012), networks are a useful tool to demonstrate complex interrelations between interrelated and dependent actors, social institutions, and technical artifacts. Chapters four and five, for example, present the resource mobilization function of capital markets by mapping the network of relations between equity owners and the CU200. Second, In response to calls for greater complexity and systems-thinking related discourse in sustainability management research (Bansal, Grewatsch, et al., 2020; Williams et al., 2017), these methods may prove particularly insightful in mapping complex networks of interactions between organizations and the environment.

Finally, we make a notable contribution to the research on sustainable and climate finance (Schmidheiny & Zorraquín, 1996). Though critical to the low-carbon transition, the study of financial actors and climate change remains largely unexplored (Diaz-Rainey et al., 2017). Findings from chapter three assert that there is an even greater gap in research on shareholder engagement and climate change. This is particularly concerning given the expansive public-facing and corporate discourse on the efficacy of engagement in influencing corporate behaviour (Berk

& van Binsbergen, 2021). We make three particularly notable contributions to shareholder engagement. First, we find that shareholder influence is concentrated among a few large owners, and consequently, these owners are best positioned to enable a low-carbon transition in the fossil fuel industry (Dordi et al., 2022). Second, in building on the ownership dynamics identified, it stands that for most financial actors, including Canadian banks and pension funds, engagement continues to be used as a distraction against meaningful action on climate change. Finally, for influential players, this research forwards a call for action to hold influential shareholders accountable for propagating climate instability through investments in fossil fuels.

6.2 Contribution to Theory

Furthering the contributions to knowledge, this dissertation presses for the urgent need for transdisciplinary theories in sustainability management for meaningful process-oriented contributions to grand challenges like climate change. We posit that amid changing markets and socio-ecological conditions, decades-old theories will not drive us into the future (Ferraro et al., 2015; Hörisch et al., 2014). Thus, sustainability scholars must resist traditional isomorphic tendencies of theory development towards homogenized interpretations and instead seek inspiration from natural and political sciences, philosophy, humanities, sociology, and anthropology. For sustainability theories to effectively address grand challenges, the next decade must bring new theoretical frameworks grounded in complexity and real-world ontologies. Indeed, sustainability, as a transdisciplinary school of thought, requires transdisciplinary theories.

We further assert that foundational theories like agency theory, institutional theory, and stakeholder theory are largely inadequate in explaining how and why shareholders may engage with the fossil fuel industry in a manner that meaningfully aligns with a low-carbon transition.

Agency theory implicitly assumes that shareholders may intervene in a firm's operations in a manner that results in higher firm performance and value maximization (Daily et al., 2003). This framework is traditionally applied to examining interventions that increase shareholder returns; however, as the industry continues to underperform, insights on proxy voting (Martin & Brooks, 2020) indicate that investors may not be meaningfully engaging with the fossil fuel industry. Consequently, it is inadequate to explain why major shareholders maintain their investments and why they may not effectively engage in the fossil fuel industry. Institutional theory, in contrast, can explain how shareholders may be influenced by both value maximization and by values and norms of the institutional environment (Bao & Lewellyn, 2017); however, it may not explain why shareholders may or may not incite a managed decline of fossil fuel production to mitigate global warming to under 2 degrees. Finally, stakeholder salience can explain why corporate governance will primarily be influenced by the largest and most influential shareholders but not what motivates shareholders to act in line with the low-carbon transition. We turn instead to theories from political science and sustainability transitions literature for inspiration.

First, the capital as power theory (Nitzan & Bichler, 2009) might explain why shareholder engagement with the fossil fuel industry might be misaligned. Under this framing, shareholder ownership is not only about an owner's ability to exert influence but also ideological power over a firm’s governance (Bichler & Nitzan, 2021). The theory asserts that shareholders might be motivated to maintain favourable market conditions as a means to mitigate against the financial risks of stranded assets, and consequently, a few large shareholders stand to gain substantially through monetizing the destruction of the world's climate (Muzio, 2016) and will continue to engage with the industry in a manner that contradicts effective climate solutions. This may explain

why prominent shareholders maintain a position of engagement and active stewardship while concurrently voting against climate-related shareholder resolutions.

Complementary to the capital as power theory is the multi-level perspective of sustainability transitions (Geels, 2002; Geels & Schot, 2007). This theory asserts that changes in landscapes and niches can drive socio-technical systems to change in incumbent regimes. As systems of regimes are slow to change (Berkhout, 2002), innovation is more likely to occur at the niche level (Seyfang & Smith, 2007), which may be driven or facilitated by exogenous landscapes of macroeconomic, political, and cultural trajectories (Burch, 2010; Geels & Schot, 2007). Interactions between regimes, landscapes, and niches can thus play a role in driving socio-technical systems change toward sustainability transitions.

In both theories, capital can be used to enable transitions if the economic and political market (or landscape) privileges those holding power. Climate-related policy interventions might thus be necessary to direct capital toward a more sustainable direction that helps to both restrict economic activities that contribute to climate instability while also mitigating financial risks.

6.3 Future Research Directions

On the topic of shareholder ownership and engagement - this research identified and measured the influence of the most prominent shareholders in the fossil fuel industry. This addresses a fundamental gap in the research, that to research and design effective interventions, we must first know who the most influential financial actors are. However, there remains a substantial gap in engagement literature on the efficacy of such interventions on climate action.

First, there is little evidence that these shareholders are, in fact, positively engaging with the industry. A cursory review in chapter four indicates that many shareholders continue to vote against climate-related shareholder resolutions (Martin et al., 2020) while simultaneously claiming to align with a net-zero transition. Thus, future research may ask what pressures shape the investment and engagement behaviour of prominent shareholders. Relatedly, there is no evidence that shareholder resolutions or involvement with voluntary coalition groups like the Climate Action 100+ have resulted in lower emissions from fossil fuel firms. Consequently, there remains a gap in research on whether shareholders have a measurable impact in enabling a low-carbon transition.

Second, in line with the multi-level perspective of sustainability, there is little research on the effectiveness and acceptability of climate-related policy interventions. Changes in the economic and political landscape through appropriate policy interventions are needed to shape the directionality of socio-technical innovation in capital markets and the fossil fuel industry. An effective mix of policy tools that are agreeable to financiers will be critical in garnering support and driving carbon reduction (Durrani et al., 2020; O. Weber et al., 2019). Yet, political uncertainty remains one of the main barriers for financial markets in participating in the low carbon transition (Hafner et al., 2020; Monasterolo et al., 2019) as the potential risks and opportunities of policy interventions are not yet understood (Carattini et al., 2021; Stolbova et al., 2018). Effective financial regulations, if carefully designed, can direct capital toward a more sustainable direction that helps to restrict economic activities that contribute to climate instability while mitigating financial risks and enabling new opportunities for low-carbon investment (D'Orazio & Popoyan, 2019; Diluiso et al., 2020).

Finally, while there is a sizable literature on the reallocation of capital away from carbon-intensive fossil fuels toward low-carbon and renewable alternatives (Bolton & Foxon, 2015; Hafner et al., 2020; Zhang, 2020), there is little research to date on the continued unsustainable developments associated with sizable incumbent investments in carbon-intensive (Antal et al., 2020). Given the expanse of incumbent investments in these carbon-intensive industries, a low-carbon transition will struggle to materialize without active engagement from key financial actors across all sectors of the economy (Naidoo, 2020). Similar methods of network modelling can thus be applied to study shareholder influence in carbon-intensive industries like mining, agriculture, construction, and transportation. Researchers may also examine whether ownership dynamics differ between fossil fuel firms and the low-carbon energy sector. Finally, does engagement differ across sectors?

6.4 Practical Implications

Revisiting the notion of adaptive expectations, we face a stark choice - to bolster fossil fuel production and face climate catastrophe or to keep fossil fuels in the ground and face trillions in potential asset stranding. Capital markets, as influential stakeholders and through their functions of resource mobilization, have a central role to play in this. The results not only assert that financial markets can influence the trajectory of sustainability transitions as enablers for socio-technical transitions but also exemplify that power is concentrated among just a handful of powerful and path-dependent financiers. Thus, we call for sustainable finance scholars to give even greater merit to research on how financial actors contribute to climate instability and their role in enabling sustainability transitions. We maintain that financing that perpetuates carbon emissions and hinders sustainability transitions should be held responsible for the climate instability caused by those emissions.

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