Institutional investor behaviour and the energy transition: A complexity framework for accelerating sustainable finance from UK investors

Kandace Persad, Bing Xu, Phil Greening

PII: S0140-9883(24)00152-X
DOI: https://doi.org/10.1016/j.eneco.2024.107444
Reference: ENEECO 107444

To appear in: Energy Economics

Received date: 4 April 2023
Revised date: 14 January 2024
Accepted date: 1 March 2024

Please cite this article as: K. Persad, B. Xu and P. Greening, Institutional investor behaviour and the energy transition: A complexity framework for accelerating sustainable finance from UK investors, Energy Economics (2023), https://doi.org/10.1016/j.eneco.2024.107444

This is a PDF file of an article that has undergone enhancements after acceptance, such as the addition of a cover page and metadata, and formatting for readability, but it is not yet the definitive version of record. This version will undergo additional copyediting, typesetting and review before it is published in its final form, but we are providing this version to give early visibility of the article. Please note that, during the production process, errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

© 2024 Published by Elsevier B.V.
Institutional Investor Behaviour and the Energy Transition:
A Complexity Framework for Accelerating Sustainable Finance from UK Investors

Kandace Persad, Bing Xu\(^1\), Phil Greening

Edinburgh Business School, Heriot-Watt University, Edinburgh EH14 4AS, UK

ABSTRACT

Despite sustainable investment flows having increased significantly over the past decade for transforming the current energy system, a large investment gap remains. This research explores the complex links between institutional investors’ expectations on the speed of the energy transition and their sustainability-related investment behaviours. Through in-depth semi-structured interviews with institutional investors, we construct a complex system model using a causal mapping approach, illustrating complex relationships within the sustainable investment system. Our contribution involves the development of multi-layer cognitive maps for different types of institutional investors, followed by a composite causal map that dissects key investment behaviours and investor expectations. Results reveal interlinked concepts influencing investment behaviour and highlight feedback loops with potential amplifying effects on investor expectations and investment behaviour. Two critical feedback loops emerge: 1) the interplay between political and financial support for the energy transition and the associated cost, and 2) the intricate relationship between sustainability factors and asset valuation. Addressing these interconnected issues simultaneously and monitor negative feedback loops that may curtail sustainable finance flows are vital. The results reveal heterogeneities among institutional investors such as fiduciary duties, stranded assets, the importance of fossil fuels in the energy system. In sum, our insights provide a foundation for holistic energy policies and a reference system for evaluating policies aimed at accelerating green finance.

Keywords: sustainable finance, energy transition, institutional investors, investment behaviour, heterogeneity of investor perceptions, policies.

\(^{\text{1}}\)Corresponding Author. Edinburgh Business school, Heriot-Watt University, Edinburgh, UK, EH14 4AS. Tel: +44(0)131 451 3294. Email: b.xu@hw.ac.uk Bing Xu acknowledges the UK Research and Innovation funding of the project “UKRI Interdisciplinary Centre for Circular Chemical Economy” (EP/V011863/1). The standard disclaimer applies.
1. Introduction

In line with commitments to limit a global average temperature increases to 1.5°C above pre-industrial temperatures, over 70 countries have set net-zero targets. The UK, a pioneer in this effort, established a legally binding net zero target of 2050 in 2019 (WRI, 2019). This ambitious goal requires a profound transformation of the current energy system, still heavily reliant on fossil resources, which constituted 76% of the UK’s total energy supply in 2020. This major transformation requires high levels of rapid investment. Current levels of annual investment in key sectors and technologies aligned with the UK’s Net Zero Energy Strategy fall within the £10 to £15 billion range. However, estimates for the capital required to meet the 2050 net-zero target range from £50 to £60 billion annually at a minimum (CCC, 2020). This represents an annual shortfall of £40 to £45 billion, a gap unlikely to be filled through public finances.

To accelerate financing levels for achieving net zero targets, attention must be directed towards institutional investors. UK institutional investors, managing approximately £8.79 trillion in assets in 2020, primarily composed of pension funds, insurance, banking, wealth funds, and other pooled investment vehicles, are crucial in bridging the financial gap for achieving net zero targets (e.g., Silver, 2017; Investment Association, 2021). Despite their substantial assets, there has been limited success in closing the investment gap for net-zero financing in the UK. This is possibly due to an overreliance on solely optimization and market-based approaches, that fail to consider the complexities of the energy transition. Investment in sustainable/energy transition initiatives by institutional investors remains limited, with less than 1% of portfolios allocated to low carbon assets in 2016. Direct exposure to fossil fuel assets during this time was estimated at 7% in equities, and the broader portfolio exposure was about 45% globally (Ameli, et al., 2020).

Recent studies argue that the energy transition and the green finance gap are complex systems, extending beyond technologies to incorporate financial, regulatory, political, and societal aspects (Hall, et al., 2017; Hafner, et al., 2020). This suggests that issues within the system are interconnected, leading to lock-in effects that reinforce negative behaviours (Unruh, 2000; Walker, 2000). This has implications on models and policy approaches used to tackle these issues (Geisendorf & Klippert, 2017). Another recurring theme in the literature is the impact of investor expectations on the speed and trajectory of the energy transition on

---

investment behaviour, sustainable energy investment, and the transition itself (e.g., Ameli, et al., 2020; Geisendorf & Klippert, 2017; Kraan, et al., 2018). While several authors have identified individual factors and concepts contributing to the sustainable finance gap, an unexplored area exists in investigating the relationship between expectations regarding the speed of the energy transition and investment behaviour (Wüstenhagen & Menichetti, 2012; Bergek, et al., 2013; Steckel & Jakob, 2018; Polzin, et al., 2019; Christophers, 2019; Ameli, et al., 2020). This highlights crucial research gaps and shows that any approach to closing the sustainable finance gap must include a consideration of these issues, in addition to the systematic effects of the existing energy system.

Our paper contributes to the field of sustainable finance through theoretical, methodological, and practical dimensions. Firstly, we develop a theoretical framework that introduces a novel approach to comprehending sustainable investment challenges, emphasising the pivotal role of investor expectations on the speed and path of the energy transitions linked in a complex system. Adopting an inductive and exploratory methodology, we employ in-depth semi-structured interviews to gauge insights related to these complex characteristics. Utilising the cognitive mapping approach, we produce a visual complex systems model that sheds light on the intricate connections, and feedback loops between key concepts, from the perspective of institutional investor stakeholders. This approach also makes major practical contributions by tackling “why” and “how” questions that are difficult to answer using traditional approaches (e.g., statistical models). Propositions are formulated instead of hypotheses in our research, acknowledging the inductive and exploratory nature of the study. The main proposition posits that investor expectations affect investment behaviour along multiple and complex pathways. Two additional propositions are put forward exploring feedback loops and connected concepts in the expectation/behavioural system that can amplify or nullify effects connected to sustainable investment behaviour.

Our results provide empirical evidence on how expectations and sustainable investment behaviours are linked along multiple pathways simultaneously and how they can be affected by feedback loops. For example, positive expectations on the speed of the energy transition affects investment scenario analysis for sustainable/energy transition assets, enhancing certainty and creating profit opportunities from the energy transition. In another pathway, anticipation of policy/regulatory changes prompts investors to augment their asset allocation and sustainable investments, as uncertainty is affected. This shows the scope for designing policy to work simultaneously along different paths. One key feedback loop found included
political and financial support for the energy transition and rising costs of the energy transition. The implication here was that rising costs connected to the energy transition can produce a negative feedback loop adversely affecting financial support for the energy transition and showed the need to carefully monitor some concepts when implementing policy. Neglecting these characteristics can contribute to ineffective solutions. In addition, we developed concepts maps to spotlight heterogeneity of investor perceptions around fiduciary duties, stranded assets, the importance of fossil fuels in the energy system. Therefore, our research outcomes offer valuable insights for designing effective energy policies. By highlighting elements that enhance positive influences on investment behaviour and minimizing negative factors (Hafner, et al., 2020), and strategically customised for specific targeted groups.

The rest of the paper is organised as follows. Section 2 covers the literature review and theoretical framework, addressing key issues and laying out the foundations for the research question. Section 3 details the methodological approach, focusing on the interviews and cognitive/causal mapping. Section 4 presents and discusses the findings, emphasising key linkages and feedback loops. The implications of these are then discussed within the framework of a complex systems approach, along with major contributions arising out of the analysis. Section 5 concludes our study and presents the basis for ongoing and further work.

2. Literature Review & Theoretical Framework

This study delves into literature spanning energy transitions and complex systems, the green finance gap and investment behaviour, with a particular focus on studies with a theoretical contribution using more inductive and abductive approaches. We survey and classify the relevant literature into three main strands. The first strand focuses on the key characteristics of the energy transition and investigates why it is important to consider the speed of the transition. The second relates to the green finance gap, institutional investors, and sustainable investment, while the third relates to complex systems.

2.1. Energy Transitions

A paramount global energy policy focus in recent decades has been the transition to a low-carbon energy system, with a contemporary emphasis on a net-zero transition. Energy transitions involve shifts in dominant technologies or energy sources, encompassing changes in technologies, finance, markets, policies, regulations, and consumptions (Araújo, 2014; Hirsh & Jones, 2014). Therefore, an energy transition requires a shift across an entire system, with
non-technical elements playing an important role in the transition (Geels, 2007; Miller et al., 2015).

Previous research highlights the importance of understanding the temporal dynamics, scale, speed, urgency, and cost of such transitions (Hirsh & Jones, 2014; Grubb, et al., 2015; Sovacool, 2016). The average duration for a large-scale energy transition typically spans between 50 and 70 years, while other partial transitions involving oil and gas have taken 80 and 70 years, respectively (Sovacool, 2016). Examining the UK’s energy landscape from 1990 to 2020 provides a nuanced perspective. Despite the existence of policies aimed at enabling a low-carbon transition, the share of solar and wind only grew from less than 1% to approximately 4.9%\(^3\), while hydrocarbon use during this time only declined from 91% to 76% (IEA, 2022). Therefore, to achieve net zero targets by 2050, the current speed of transition needs to be greatly accelerated.

Uncertainty around speed of the energy transition is important as it carries implications for investor expectations on the future. Previous studies have defined investor expectations on the future as being heterogeneous in nature (Kraan, et al., 2018; Christophers, 2019) with these expectations having an effect on current investment behaviour (Geisendorf & Klippert, 2017; Christophers, 2019). Therefore, understanding how these factors work together to impact investment behaviour can enable more effective policies to be designed to change investment behaviour. This research focuses on expectations on the speed of the energy transition and its effect on investment behaviour, as speed represents one of the key characteristics of an energy transition (Sovacool, 2016). This was also pointed out in the literature as an important characteristic affecting investment behaviour (Ameli, et al., 2020), although to date, there has been no research geared towards this. Therefore, finding the link between investor expectations on the speed of the energy transition and investment behaviour represents an important aim to be determined and forms the basis of the research question and objectives.

2.2. Existing Problems and Limitations in Closing the Financing Gap

Despite global efforts to mobilise funds for a net-zero transition, attracting sufficient finance, especially in the private sector, has been challenging. This can be attributed to the assumptions in energy finance that markets are efficient, and capital will flow to low-carbon energy once prices align with the fossil sources and technologies (e.g., Unruh, 2000; Foxon,
This assumption underpins energy policy aimed at attracting financing for decarbonisation. The implication is that policies focus primarily on market-based instruments and transparency initiatives (Ameli, et al., 2020).

Another area highlighted in the literature is the treatment of investors as a homogeneous group when designing policy or structures aimed at increasing low-carbon financing (Kraan, et al., 2017; Barazza & Strachan, 2020; Lamperti, et al., 2020). Work done by Bergek et al. (2013) and Christophers (2019) show that there is heterogeneity in investor expectations on climate change. However, models used in the analysis of energy transitions rarely account for heterogeneity and adaptive behaviour as it relates to investors (Geisendorf & Klippert, 2017; Barazza & Strachan, 2020). One implication of not dealing with heterogeneities is that policies can be designed that exclude many types of investors not fitting into the selected characteristics (Bergek, et al., 2013).

Other highlighted problems relate to the understanding of investment behaviour, particularly as it relates to energy finance. Wüstenhagen & Menichetti (2012) and Hirth & Steckel (2016) pointed to these issues in their work on investment behaviour in the energy space resulting in limited effectiveness of energy policies. While these studies show factors affecting investment behaviour and represent an important step in developing effective policy, there is a need for understanding how such factors link with investor expectations, barriers, actors and institutions (Hafner, et al., 2020). Recent studies in this area have argued for the need for a more holistic approach in addressing these problems (Wüstenhagen & Menichetti, 2012; Hirth & Steckel, 2016).

We contribute to this line of research by using a complex systems approach and the three domains framework of sustainable/energy transition finance to address issues related to the complexity of the energy transition, heterogeneity, and investment behaviour (Grubb, 2014; Hall et al., 2017; Ameli et al., 2020). Complex systems and the three domains framework will be discussed in the rest of this section.

2.3. Complex Systems

Complex systems arise from the dynamic interactions among agents and elements within a system, leading to intricate behaviours shaped by constant changes, interactions, feedback loops, disproportional effects, dependence on historical pathways, self-organization of elements and adaption of the system (Simon, 1996; Thompson, 1967; Anderson, 1999;
Sterman, 2000). These characteristics often lead to policy-resistance (Sterman, 2000; Geurts, et al., 2007). Hafner et al. (2020) demonstrate that the green finance gap displays the characteristics of a complex system as defined by Sterman (2000). These characteristics are: 1) interconnectivity (i.e., various relationships and connections within various system components), 2) path-dependence (i.e., a state of a particular element or combination of occurring as a result of previous actions or decisions taken, with the state reinforcing itself and thereby resulting in actions being ‘locked in’) (Unruh, 2000; Walker, 2000; Koch, et al., 2009), 3) observed or generated behaviour (i.e., emergent behaviour occurs in a system as a result of all the components of the system and its interactions, which is opposite to models that converge toward a particular equilibrium), 4) non-linearity (i.e., sudden, random and disproportionately large changes triggered in the system), 5) dynamic behaviour (i.e., the constant changing of the components and states within the system), and 6) multidisciplinary components (i.e., systems are usually transdisciplinary in nature as various fields and subjects interact to form a system) (Sterman, 2000; Koch, et al., 2009; Meadowcroft, 2009; Bakker, 2014; Hafner, et al., 2020).

Hafner et al. (2020) demonstrated that a complex systems approach can be appropriately applied to the analysis of solutions for closing the green finance gap by showing that the green finance gap displayed these characteristics. However, the study did not formulate a comprehensive complex system model or delineate precise linkages between system components. In other studies pertaining to energy finance and institutional investing, Silver (2017), for example, highlights the risks related to stranded assets were largely ignored in the financial industry, advocating for a complex systems approach. He demonstrates that institutional investors, constrained by measuring risk against a particular benchmark, often overlooked stranded asset risk. The potential consequences include significant devaluation of institutional investors’ portfolios if fossil fuel assets were to become stranded (Silver, 2017). Therefore, the use of a complex systems approach to sustainable finance can be useful in considering long term risks to institutional investor portfolios.

Another emerging theme in the literature underscores the limited effectiveness of policies designed to expedite sustainable/energy transition finance. Employing a complex systems framework reveals that policy resistance stems from interpreting experiences as isolated events, resulting in an event-oriented problem-solving approach that may not account for feedback loops within the system (Sterman, 2000). Thus, a key objective of this research is to identify and understand the feedback loops within the system. These feedback loops, as revealed in our
study, are presented in the Results and Discussion section, along with the discussion of the implications.

2.4. Three Domains Framework for Energy Finance

The pivotal Three Domains Framework, originally formulated by Grubb et al. (2014) in economics, serves as a cornerstone for this study. This framework posits that the evolution of energy systems demands a comprehensive understanding and application of three domains encompassing socio-economic processes and decision-making modes. These domains are categorised as satisficing, optimising, and transforming. Correspondingly, the first domain pertains to behavioural aspects, the second domain centres on market efficiency, and the third domain revolves around systems change or evolution (Grubb, et al., 2015). The extension of this framework in finance and energy was carried out by Hall et al. (2017) and Ameli et al. (2020) respectively. The argument was that modelling and policy related to energy finance focused on the second domain (market efficiency), while the first and third domains remained underexplored (behavioural and transformation). As a remedial measure, our research strategically applies this framework to integrate all three domains with a particular emphasis on the less-explored ones. The incorporation of a complex systems approach facilitates the interconnectedness of these three domains. Therefore, our research builds upon the foundations laid by Hall et al. (2017) and Ameli et al. (2020) by constructing a complex systems model cutting across the behavioural, optimization and transformational domains. This model effectively links key concepts and issues within these domains, presenting a unified and coherent framework.

3. Methodology

A complex systems approach is used in the research design, methodological approach, and analysis of results. The development of this model firstly requires tools aimed at eliciting and representing mental models (Sterman, 2000). The tools used in this case for data collection is in-depth semi-structured interviews from the investors’ perspective, while for data analysis, cognitive mapping was used. These choices are also consistent with an interpretivist research paradigm (Eden, 2004; Pyrko, et al., 2017) which is suitable for the purpose of creating a model from the perspective of institutional investors. The implication of using this perspective is that it allows for the development of more targeted policy towards this group.

3.1. Data Collection
An overview of the main steps involved in this study phases is given in Figure 1. We carried out in-depth semi-structured interviews on 15 institutional investors. Interview questions were developed and validated in a multi-stage process. Firstly, an initial list of questions was developed based on a comprehensive review of the literature (e.g., academic journals, investment reports, investor surveys) related to the energy transition and institutional investors. These questions were based on themes emerging from the literature most relevant to the research questions and aims. Secondly, we validated our questions in two rounds by experts in the related fields as shown in Figure 1. The final list of interview questions used in the research is presented in Appendix 1 below, which reflects the integration of research aims and both rounds of feedback from experts.

Figure 1: Overview of main steps in interview & cognitive mapping phase

Data was then collected using the validated semi-structured interview with questions focused on the relevance of the energy transition to investment behaviour, expectations on the speed of a net zero UK energy transition along with the main factors affecting those expectations, investment behaviour as it relates to sustainability and limiting factors with respect to sustainability. Within these questions, additional questions were asked based on emerging discussions in the interview to follow up on additional important issues. This was done as structured questions enable different interviews to be compared while the additional questions enable insights from each interview on concepts not included in the interview to be
abstracted (Bryman, 2012; Saunders & Townsend, 2016; Spanellis, et al., 2021). This allowed for additional insights to be generated on the topic.

While there has been some inductive research in this area, most research with a focus on sustainable finance and investor expectations rely on deductive approaches. As this research attempts to derive more knowledge in the first domain (behaviour) and underexplored third domain (transformation), in addition to linking concepts across the three domains, an inductive method is more valuable (Saunders, 2015). A sample size of 15 to 20 interviews was selected to develop a robust theoretical contribution using in-depth analysis. Previous qualitative studies around sustainable finance using an inductive approach used between 16 to 25 interviews. Therefore, the sample size chosen in this case is in line with previous studies of a similar type⁴.

The interviewees are strategically chosen to reflect the diversity of institutional investors in the UK. The sample composition, guided by investor surveys, is designed to encompass: 1) different types of institutional investors in the UK and experts and consultants connected to the area⁵; and 2) a variety of behavioural styles with respect to sustainability and the energy transition⁶. Given that pension funds constitute a significant share of institutional investors’ assets and play a key role in sustainable investment, they dominate the sample. Asset managers and insurance companies complement the diversity. In addition, we include consultants and experts in the sample enhances the depth of knowledge and engagement with investors on these critical issues. Investors in this group also cross a range of behavioural styles and level of ESG and sustainability integration. The purposive sampling method was employed, ensuring access to the target group and the ability to obtain detailed insights. This is a suitable approach for addressing specific research objectives, especially when the target group may be challenging to access or lacks the required knowledge to participate in the research (Saunders, et al., 2019).

3.2. Methodological Approach for Data Analysis

A cognitive and causal mapping approach was selected here as it is uniquely positioned to address the research problem and question. A data analysis method was also needed to address

---

⁴ Guidance on exact numbers of participants varies amongst different studies. Saunders (2012) recommended 12 to 30 participants for heterogenous studies, while Kuzel (1992) recommends 12 to 20 participants (Saunders & Townsend, 2016). Due to the depth of each interview and the analysis techniques used on each interview i.e. cognitive and causal mapping and centrality and loop analysis, 15 to 20 interviews were deemed as being appropriate to keep within the time limits of the research.

⁵ These include pension funds, insurance, asset managers, wealth managers, pooled investment vehicles, investment consultants, policy makers and academics.

⁶ This includes investors with no part of their portfolio sustainably invested, those with part of their portfolio invested and those with a strong focus on sustainable investment.
problems with complex systems characteristics like path dependence, feedback, and dynamic behaviour. The links and interdependencies in the system was also key to our analysis. These requirements eliminated many solutions that ignore these characteristics. An inductive method was also required to derive rich and complex knowledge (Saunders, et al., 2019), showing various contexts and relationships (Rees, 2018). This is particularly important when generating inductive research and addressing ‘how’ and ‘why’ questions (Yin, 2018) that require deeper analysis. In addition, cognitive mapping techniques are appropriate when addressing perceptions and behaviours (Pyrko & Dörfler, 2017) which is relevant as we explore investor expectations and investment behaviour, while providing an appropriate theoretical framework. This addresses a major gap in the sustainable finance field, while cognitive mapping offers a novel approach in this area.

For the interviews prepared for cognitive mapping, established guidelines by Eden and Ackermann (1998) and Pyrko and Dörfler (2017) were initially followed. However, due to the variations in the research aims, purposes and objectives, adaptations were made to the method. In the method used by Eden and Ackermann (1998), maps were divided into three main categories i.e. goals, strategic directions and options, where goals represent the main reference points for mapping, while strategic directions represent actions needed to enable these goals and options represent possible solutions (Eden & Ackermann, 1992; Eden & Ackermann, 1998; Eden, 2004; Pyrko, et al., 2017; Pyrko & Dörfler, 2017). The main modifications in this case were related to the mapping model structure, which relied on the research questions and interview structure. The research and interview questions replaced the traditional goals set out in the mentioned recommendations, while the main concepts in the interviews took replaced the strategic directions, while the points and actions flowing from that replaced the options. The map is built around expectations and behaviour as per the research question. The main concepts from each map were extracted and ranked using centrality analysis for each map, which produced a list of the most important concepts. This was the main determinant for the structure and layers of the map. This was then used to fill in the rest of the map. Surrounding concepts and heterogeneities were then added to the maps for context. This was done to preserve the most important concepts and the relevant context.

For each interview, a substantial number of concepts, ranging from 150 and 400, were generated. Due to the complexity of these maps and the space constraints that restricts displaying large number of concepts, two types of summary maps were created for each interview instead of using the original maps. This decision aligns with the approach taken by
Rees et al. (2017), who faced a similar challenge in dealing with cognitive maps. In their method, they initially created a causal map with 199 concepts, finding it overly complicated for comprehensive analysis. To reduce the number of concepts, they applied a thematic model, resulting in a condensed map featuring 30 concepts.

The modified steps are summarized below:

**Step 1** – Map preparation.

**Step 2** – Building the cognitive map hierarchy.

**Step 3** – Arrangement of concepts in the map under headings in hierarchy.

**Step 4** – Conversion of originally built maps into summary maps.

**Step 5** – Validation of maps.

**Step 6** – Set-up for analysis.

**Step 7** – Merging of individual maps into a causal map model.

**Step 8** – Validation or testing of model.

In our study, the first summary map type (Summary Map Type 1) contained an average of 60 to 90 concepts, designed to fit on a single A4 page. The second summary map type (Summary Map Type 2) featured 15 to 40 concepts, strategically selected for their utmost relevance to the two variables under scrutiny - investor expectations on the speed of the transition and investment behaviour. This type of map shows the most critical links between the two variables within a complex system. Figure 2 illustrates an example of this map, with additional examples in the Appendices. The individual summary maps (Type 2) were combined into one map, forming a causal map of the main concepts most relevant to the research question, striking a balance between conciseness and retention of pivotal concepts and interconnections. This is shown in Figure 3 in the next section.

Furthermore, we apply the centrality analysis to the original cognitive maps to identify statements with the highest influence on the model, gauged by their extensive causal links within the wider map. This analysis was executed using the Decision Explorer software’s centrality function, generating a roster of the most influential concepts for each individual cognitive map. These concepts were then compared amongst the various interviews and then a merged listing of overlapping concepts was produced. This was also used to verify the results from the causal map, which reflects the merging of concepts from individual maps. The key emergent concepts are detailed in Section 4.2.2 in Table 1.
The validation of the maps involved a dual approach. Initially, the interviewees were provided with the completed models to be validated. Alongside the models, a concise explanation and copies of the interview question list were supplied. This afforded the interviewees an opportunity to suggest modifications or confirm the accuracy of the model based on their perspectives. Secondly, the model has been used as a reference for a game design, which was in part used to further test and explore findings from this model. This is a separate piece of work, not included in this paper. The games conducted also validated the results in a targeted environment with more participants.

4. Results & Discussion

In this section, the results from the cognitive mapping process will be shown, along with the merged causal map. The implications of these results will be discussed, along with key contributions arising from this. The results from the cognitive and causal mapping process are displayed in the form of a map to demonstrate the complex system around investor expectations and sustainable investment behaviour, along with the key concepts and feedback loops. The maps also illustrate characteristics of a complex system. Individual cognitive maps are displayed in Figure 2 and Figures A4 to A10 in the Appendix, while the merged causal map is featured in Figure 3. To elucidate our analytical approach, we initially present and discuss a summary cognitive map from one interviewee in the next two sub-sections. Subsequently, we provide a collective analysis of all the maps.

4.1. Description of Example Cognitive Map

Figure 2 presents an example of a summary map of from an asset manager, with the first two iterations of this map given in the Appendices (Figures A1 and A2). Three key links between investor expectations on the speed of the energy transition and investment behaviour are summarized below. Firstly, there is a vital link between the recognition of the significance of the energy transition by financial markets and the expectations for a rapid transition, grounded in the belief that economies can swiftly attain established targets. This perception opens opportunities within the energy transition, providing avenues for generating returns and positively influencing investment behaviour, particularly in the realms of sustainability and the energy transition. Secondly, investor expectations wield a substantial impact on financial forecasts, leading to heightened investments in sustainable/energy transition investments. This increased commitment instils greater certainty and fosters higher growth, thereby positively affecting the valuation of sustainable/energy transition investments. Lastly, the current outlook
on the energy transition anticipates a medium to fast-paced transition, primarily steered by factors such as financial markets and political capital. Any reversal of these factors increases the perceived risk associated with the energy transition. This consequently negatively impacts investment behaviour in terms of sustainability and the energy transition.

**Figure 2:** Summary map 2 based on Interview #1

In the context of the speed of the energy transition, the prevailing expectation is for a quick transition, without reaching key net zero targets by 2050. This was denoted by a speed of 4 out of 5. This optimistic outlook is underpinned by the *acknowledgement of the energy transition* by financial markets and the *political capital supporting* the energy transition. These were seen to drive regulation and investment which was also largely perceived in a positive light. However, it was pointed out that there was a potential risk of these factors turning negative in the future under some scenarios, such as the *high public cost of the energy transition*, exemplified by the prospective expense associated with mandatory electric vehicles. Another envisaged risk involves *reduced investment in oil*, resulting in diminished hydrocarbon supplies and a corresponding increase in oil price, potentially redirecting capital back to oil companies.
Additionally, despite the positive outlook on the transition speed, concerns about meeting net zero targets for 2050 persist due to perceived inadequacies in the requisite technologies.

The impact on investment behaviour in this map is multi-faceted. Political and financial support for net-zero influences investment behaviour in one route, while expectations on the speed of the energy transition impacts investment behaviour via financial forecasts in another route. More positive expectations correlate with enhanced financial forecast, fostering heightened certainty in sustainable investment opportunities. Increased certainty, in turn, contributes to elevated growth and valuation of sustainable and energy transition assets.

However, overarching these factors, the dominating factor superseding sustainability and energy transition is uncertainty (Caglayan and Xu, 2014; 2019). There appeared to be numerous unknowns, spanning politics, duration, technology, and resources, contributing to a cautious approach in augmenting sustainable investments. An example given was the uncertainty as to which technology would be dominant in the transport sector in the future (i.e., electric vehicles or hydrogen). Such uncertainties introduce a sense of caution, hindering a more significant increase in sustainable investments.

In summary, the illustrated links show the relationship between investor expectations and investment behaviour, revealing the main factors and concepts affecting these linkages. This complexity highlights the nuanced interplay between the two variables. An important implication is the need to consider multiple concepts, including their relationships and contexts, when formulating energy policy intended to influence investment behaviour and stimulate financial flows toward sustainable investments and the energy transition. This will be further discussed in the Relevance/Contribution of Key Findings Section.

4.2. Causal Map

This section describes the analysis from all maps. Firstly, a discussion on the overall complexity of the results is presented. Next, the main overlapping concepts are discussed, followed by a discussion of the heterogeneities within concepts.
Figure 3: Causal map – merged map of individual cognitive maps
4.2.1. Complexity in Results

The causal map shows the complex system existing between expectations on the speed of the transition and investment behaviour. This can be demonstrated using the characteristics discussed in the Literature Review section. This subsection picks out some key features of complex systems and their implications for the research question.

1) Feedback loops in the investment system

Feedback loops in the system can result in the development of amplifications and lock-in effects (Sterman, 2000; Unruh, 2000; Hafner, et al., 2020). Positive feedback loops amplify specific actions, outcomes, or behaviours within the system, while negative feedback loops counteract resultant changes in the system (Sterman, 2000). Figures 4a and 4b show examples of positive and negative feedback loops, respectively, in the causal map.

In the positive feedback loop example, fiduciary duties dictate pension funds’ obligation to fulfill client or pension payouts. The integration of sustainability factors into investments influences assets values, impacting the ability to meet these obligations. All these factors combine to form a feedback loop that creates an amplifying effect as shown in Figure 4a.

**Figure 4 Example of feedback Loops**

a. A positive feedback loop  

b. A negative feedback loop

In the example of the negative feedback loop in Figure 4b, support from politics and financial markets are currently deemed to be positive. Hence, regulations on making low carbon technologies like electric vehicles mandatory can result. However, if the cost remains high so that electric vehicles are unaffordable to general public, political and financial backing will wane, counteracting support for the energy transition.
Feedback loops can also have wider systematic effects. In the case of the negative feedback loop, the level of risk attached to the energy transition and connected assets can also be affected, as well as the credibility of the UK’s net zero strategy. Therefore, a reversal of support can trigger the feedback loop, amplifying the impact on the overall system.

2) Emergent investor expectations and investment behaviour

Complex systems often yield emergent behaviour rather than converging toward equilibrium (Sterman, 2000; Hafner, et al., 2020). The causal mechanism in the system generates emergent states based on expectations regarding the speed of energy transition or the level of sustainable or energy transition investments. The cognitive map in Figure 2 illustrates how interconnected factors contribute to a moderate to fast expectation of transition. Factors such as financial market support, political support, and regulations positively affected expectations, while the perception that the ability to meet targets are not within the system, in addition to the potential reversal of support for the positive factors mentioned negatively affected expectations. The emergent behaviour in terms of the expectation on the speed was for a moderate to fast transition without hitting key targets or hitting net zero by 2050.

From an investment behaviour perspective, opportunities, and risks\textsuperscript{7} are key factors. In the cognitive map, opportunity was assigned a higher weighting by the investor than risk as opportunity was seen as a more immediate factor. Therefore, these factors led to a state of investment behaviour. In this case, it increased the valuation of equities connected to the energy transition like those related to renewable energy. Therefore, the state of the system, influenced by various factors, leads to emergent investor expectations and investment behaviour.

4.2.2. Main Overlapping Concepts

Table 1 outlines key overlapping concepts that significant influence individual models within the wider map. This was determined by a combination of centrality analysis and manually picking out key concepts from the maps. These were then arranged by category and tallied to give the main overlapping concepts.

The concept of “risk” emerges prominently in the cognitive maps, encompassing various risk types to streamline the map. In the casual map, risk is interconnected with multiple arrows representing its multifaceted influences. The uncertainty arising from unknowns in politics,

\textsuperscript{7} Opportunities arising in the markets to make money from the energy transition, whereas the risk refers to the investments being negatively impacted.
resources, and relevant technologies contributes to the risk, as does the potential reversal of support for a net-zero transition. As seen by the outward arrows, risk impacts investment scenario analysis and financial forecasts, and ultimately, investment decisions, becoming a pivotal consideration in many cases.

Two-way arrows connecting risks to other concepts underscore their reciprocal impact. For example, the bidirectional arrow between “risk” and “short-term vs. long-term priorities” highlights how risk influences the prioritisation of factors in investment decisions. One example was that oil price was seen as a more critical in some valuations than climate change or energy transition issues, which are seen as long-term. The implication of this is that oil price would be given a higher weighting and in the case of a high oil price, investments will flow to assets positively affected by a higher oil price. This is despite the long-term risk to achieving a net zero energy transition. Therefore, the influence of risk is substantial and evident in its numerous links with other concepts and its intricate connectivity with the map.

**Table 1: Most important overlapping concepts**

<table>
<thead>
<tr>
<th>Policy (past change produced, future change)</th>
<th>Actions or clear roadmap to support net zero targets/commitments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy transition and climate change issues having more impact on the valuation of assets</td>
<td>Regulation (impact on companies, increasing regulatory activity on energy/climate change issues, increasing importance of regulations in the future)</td>
</tr>
<tr>
<td>Externality/carbon pricing</td>
<td>The importance of the energy transition as a structural drive in the long-term</td>
</tr>
<tr>
<td>Fiduciary duties</td>
<td>Differences in scenarios/ climate change scenarios</td>
</tr>
<tr>
<td>Supporting infrastructure to support the transition (e.g. charging points for electric vehicles)</td>
<td>Building new sustainable products for clients</td>
</tr>
<tr>
<td>Lack of data/weak data for some asset classes</td>
<td>Disruption</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>Current dependence on fossil fuels and need for investment</td>
</tr>
<tr>
<td>Ambiguities/changes in definitions of sustainability (e.g. natural gas and nuclear)</td>
<td>Unrealistic targets/lack of capacity in the system to achieve targets</td>
</tr>
<tr>
<td>Engagement and divestment</td>
<td>Winners and losers in the energy transition</td>
</tr>
<tr>
<td>Stranded assets</td>
<td>Opportunities (from renewable energy technologies but also from high oil prices)</td>
</tr>
<tr>
<td>Political support</td>
<td>Demand creation and destruction/ electric vehicle technologies</td>
</tr>
</tbody>
</table>

‘Uncertainty’ was another key concept mentioned in most maps, exerting a negative impact on both investor expectations and investment behaviour. The absence of a clear roadmap in certain sectors adversely affects the credibility of the UK’s net zero strategy and the expected speed of the energy transition. Uncertainty hampers the ability to formulate a clear roadmap,
playing a big role in shaping expectations regarding the pace of the energy transition. On the investment behaviour front, uncertainty negatively impacts valuation, which feeds into investment behaviour. For example, uncertainty regarding preferred technologies in a net zero energy transition (e.g. electric vehicles versus hydrogen) leads to cautious valuation of related assets, restricting the allocation of investments toward sustainability and the energy transition. Thus, uncertainty exerts a significant link on the model on both ends when considering the level of connectivity with the rest of the map and the links to other concepts. In addition, the role of carbon pricing in facilitating the energy transition has also been highlighted (e.g., Tan et al., 2023). In summary, the high level of overlap amongst various concepts creates opportunities for policy to be designed to exploit these similarities.

4.3. Heterogeneities and Opposing Viewpoints within Concepts

A major problem in closing the finance gap from the literature review was the treatment of the investor group as homogeneous. This is despite studies pointing to the heterogeneity of investor perceptions as it relates to issues on climate change, as shown in work done by Bergek et al. (2013), Christophers (2019) and Kraan et al. (2019). This pattern is also reflected in findings from interviews, revealing both overlapping concepts and differing perspectives on various concepts. Several concept maps were developed to spotlight these heterogeneities, using key concepts as focal points. One trend observed in the interviews was that fiduciary duties vary amongst institutions, even for similar types. This involves taking actions in the best interest of the client or trustee. While some pension funds view climate change and energy transition issues as part of their fiduciary duty, others do not interpret these issues as being part of their responsibility (Jansson, et al., 2014). This effect is that shorter-term factors are prioritized, resulting in climate change/energy transition issues being less relevant to their current investment decisions. This contributes to a range of behaviours even in similar types of institutional investors with respect to the integration of climate change/energy transition issues in their investment. Figure 5 highlights some of these heterogeneities. Fiduciary duty can relate to investment through increased client demand for sustainable investing, more engagement from clients on energy transition issues and more regulatory constraints on clients. One example of this is from asset managers investing on behalf of insurance and pension fund clients. Increased pressure from regulators for reporting and disclosure of climate and energy transition risks and opportunities on these clients mean that asset managers would have to integrate these issues into their investing. The implication of these differences is that various types of investors may be limited in adjusting their levels of sustainable investment.
The issue of *stranded assets* was consistently ranked as an issue of significance by several interviewees. While many perceived stranded assets as a significant risk concerning net zero targets, a few argued that the issue was overstated, citing the indispensable role of fossil fuels in the current energy system. In other interviews, even though the issue of stranded assets was not specifically mentioned, it was pointed out that they perceived that a net zero energy transition was not feasible as there was not capacity in the system for this to occur. This reflects the range of views connected around this concept and highlights the complexity in developing appropriate policies and regulations.

Figure 6 illustrates heterogeneities around the *importance of fossil fuels in the energy system*. It shows the two diverging views on importance. From the map, stranded assets were seen to be associated with energy transition risks and portfolio damage, particularly over longer time horizons. For a perceived high importance of fossil fuels to the energy system, the map shows that there is continued investment in oil and gas assets, which creates a feedback loop that reinforces the importance of fossil fuels to the energy system. A further point made was that oil and gas assets could be undervalued in the short-term, due to climate change and energy transition issues, allowing for value investment opportunities.

These heterogeneities highlight the need for clear, coherent, and non-contradictory targets, policies, and regulations. Conflicts in priorities are likely to persist into the future, this shows that careful steps should be taken to minimize the impact of these contradictions. Forecasts indicating continued growth in oil demand for the next five years, with a peak at 105.7 million barrels per day in 2028 (International Energy Agency, 2023), even as the energy transition intensifies. To support this, there will inevitably be continued fossil fuel investment. Policies and regulations will need to balance this clearly in the long-term. Failing to do so will likely result in increased uncertainty in the energy transition (Flora & Tankov, 2023), which can lead to investment delays and the locking in of negative related environmental and economic consequences (Geisendorf & Klippert, 2017).

### 4.4 State of Sustainable Investment Using UK Pension Funds as An Example

Table 2 illustrates key climate-related metrics sourced from an analysis of Task Force on Climate-Related Financial Disclosures (TCFD) reports, focusing on the seven of the biggest pension funds in the UK.
Figure 5: Concept map - fiduciary duty
Figure 6: Concept map - fossil fuels in the energy system
In the context of 2022, the data underscores a persistent issue with elevated financed carbon emissions intensity. Notably, the benchmark values for equities and credit, established at 41 tCO2e/£m and 69 tCO2e/$m respectively (Pension Protection Fund, 2023), emphasize the need for sustained efforts to align with more stringent targets. This is particularly crucial as most pension funds deviate from these benchmarks, contingent on their portfolio compositions. Furthermore, it is essential to recognize that the reported figures only encompass Scope 1 and 2 data, leaving a gap in accounting for Scope 3 emissions. While some pension funds in this table have initiated efforts to estimate Scope 3 emissions, significant disparities exist. For instance, in the case of the largest pension fund, the Scope 3 emissions intensity was approximately 4.5 times higher than the reported Scope 1 and 2 emissions intensity (Universities Superannuation Scheme, 2023).

**Table 2:** Key climate-related metrics for seven UK pension funds in 2022

<table>
<thead>
<tr>
<th></th>
<th>Asset under (AUM)/£billion</th>
<th>% AUM covered</th>
<th>Emissions intensity (tCO2e/£m)</th>
<th>Scope included</th>
<th>% Portfolio alignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>USS</td>
<td>75.5</td>
<td>67</td>
<td>70.7</td>
<td>1 &amp; 2</td>
<td>24-27&lt;sup&gt;9&lt;/sup&gt;</td>
</tr>
<tr>
<td>BT</td>
<td>37.3</td>
<td>70</td>
<td>199</td>
<td>1 &amp; 2</td>
<td>33.6-45.1&lt;sup&gt;10&lt;/sup&gt;</td>
</tr>
<tr>
<td>Natwest</td>
<td>35.7</td>
<td>83</td>
<td>73.2</td>
<td>1 &amp; 2</td>
<td>20&lt;sup&gt;11&lt;/sup&gt;</td>
</tr>
<tr>
<td>PPF</td>
<td>32.5</td>
<td>55</td>
<td>60.1</td>
<td>1 &amp; 2</td>
<td>43&lt;sup&gt;12&lt;/sup&gt;</td>
</tr>
<tr>
<td>Railway</td>
<td>34</td>
<td>77</td>
<td>59</td>
<td>1 &amp; 2</td>
<td>1&lt;sup&gt;13&lt;/sup&gt;</td>
</tr>
<tr>
<td>HSBC</td>
<td>27.5</td>
<td>38</td>
<td>47.29</td>
<td>1 &amp; 2</td>
<td>14&lt;sup&gt;14&lt;/sup&gt;</td>
</tr>
<tr>
<td>Barclays</td>
<td>25.4</td>
<td>63.6</td>
<td>50.7</td>
<td>1 &amp; 2</td>
<td>23.1&lt;sup&gt;15&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Despite the considerable challenges outlined, numerous pension funds have set ambitious net-zero targets, signifying a commendable advancement in sustainable investment practices. However, this data reveals the persistent gaps and challenges that still exist, highlighting the ongoing need for concerted efforts and strategic initiatives within the financial sector. This point is illustrated by examining the current portfolio alignment, which shows the percentage...
of portfolio currently aligned with a 1.5-degree energy transition pathway. In most cases, this alignment occurred over a small percentage of the portfolio. It is also important to note that a significant percentage of AUM is not covered in the TCFD analysis, as there remains key data gaps. This shows the need to understand the complexities of sustainable investment behaviour and how this can be changed. The causal map model of the system contributes to covering these gaps in knowledge and points to potential areas of change that can be exploited.

5. Conclusions

Our paper introduces a holistic framework to address challenges associated with sustainable and energy transition finance flows from UK institutional investors. This framework facilitates the design and testing of effective policy solutions, showing areas where sustainable investment behaviour can be significantly impacted by grouping linked concepts and targeting key feedback loops and pathways. The main findings and implications are set out in this section.

Firstly, the mapping process revealed a complex system framework connecting investor expectations on the speed of the energy transition and investment behaviour, highlighting crucial concepts, linkages, and feedback loops. Sustainable investment behaviour can be affected along multiple paths simultaneously, leading to amplified positive or negative effects. For example, scenarios with negative factors affecting investor expectations on the energy transition can translate into a strong negative impact on sustainable investment levels. Therefore, managing investor expectations along various pathways is integral for achieving targets. Based on this, we recommend the development of coordinated policies to tackle various factors affecting investor expectations simultaneously. The model indicates that factors connected to perceived fossil fuel dependence and net-zero policy credibility play a key role. Additionally, regulations aimed at increasing certainty for energy transition assets owned by pension funds can produce higher positive effects when addressing multiple paths concurrently. Hence, future work should be aimed at testing policies that could affect multiple paths simultaneously.

Secondly, the presented maps incorporate both positive and negative feedback loops that can amplify or counteract expectations and behaviours in the system. The importance of political support for the energy transition (Becker, et al., 2019) has been highlighted in the literature but not tied to amplification effects. Factors, such as high energy transition costs, negatively affecting political and financial support, can lead to amplified negative effects on the system. Therefore, policies aimed at mitigating such factors (e.g., costs) would be necessary for the
The success of financing policy. Feedback loops provide opportunities to rapidly increase sustainable finance, and further research should explore interventions to amplify the effects of positive behaviours or counteract the effect of negative behaviours, given the significant consequences observed in the maps. The model provides the theoretical basis for this, as it shows the flows and connections of the loop. Practical uses for this can then be established by designing policy around these feedback loops like the one involving the integration of sustainable issues more closely with sustainability issues. It is recommended that further work should be aimed at intervening in the feedback loops presented here to either amplify the effects of positive behaviours or counteract the effect of negative behaviours as consequences can be significant as seen in the maps.

Thirdly, the system analysis indicates the interconnection of specific concepts/issues and should be addressed holistically to significantly impact investment behaviour. In the casual map model, an example of a grouping would be uncertainty, valuation, and investment behaviour, with many other issues being connected to uncertainty. The theoretical implications of this interconnectedness suggest that these concepts can be treated collectively to harness positive effects on investment behaviour rather than addressing concepts in isolation. Furthermore, our examination reveals heterogeneities in investor perceptions and behaviours. The practical implications and avenues for further work revolve around the design of policies for different groupings. For example, the issues around uncertainty can be addressed in the same policy package, particularly concerning valuation and scenario analysis. In addition, circular economists caution that while energy efficiency and the transition to renewables are pivotal, they account for only 55% of emissions, the remaining 45% necessitates a transition toward a circular economy (e.g., Xu et al., 2021; Marques-McEwan et al., 2023). This prompts an interesting avenue for extension, urging a deeper examination on institutions investors’ investment behavioural towards circular economy practices. We recommend that further work should be done to further test specific policies in a dynamic environment.

It is important to note that this study was carried out in a UK context and these findings are related to UK institutional investors. We recommend that similar studies be carried out in other regions for comparisons. Nevertheless, this study provides insights that can be extrapolated for certain comparative analyses. For instance, feedback from some interviewees pointed out that when compared to the UK, the EU has more stringent rules around climate-related disclosure and actions, which inevitably impacts investment behaviour. In the context of developing markets, interviewees emphasized challenges related to data quality and
availability, posing additional barriers to sustainable investing. Rules concerning climate-related disclosure and action were perceived to be less stringent in some developing markets. This affected investor expectations on the speed of a global energy transition versus the speed of a UK energy transition. While most investors anticipated a medium speed for the UK’s energy transition, they expressed a belief that the global energy transition would be slower, based on perceived slower progress in developing countries. Given the conclusions of this research that investor expectations do affect investment behaviour, this can potentially have negative impacts on future sustainable private investment in these regions. It would be useful to investigate further the interplay between investor expectations, regional regulations, and global progress.

In summary, our results contribute to furthering the work on understanding institutional investor expectations and investment behaviour as it relates to the energy transition and therefore to understanding how investment flows may be increased in this area. Each of the recommendations given in this section involves the testing of policies within the model. The results obtained from these tests serve a dual purpose: they not only validate the model’s outcomes but also contribute to a nuanced understanding of its limitations. We suggest that this research should be extended to encompass various types of financial institutions and countries. Note that models will need to be adjusted in this case to reflect the environment in each country. Furthermore, there is a compelling case for additional work for testing specific regulations and policies. While this model offers general categories of regulations and policies that may produce significant effects, additional testing can uncover specific regulations and policies that may be more effective. For future research, we will test our concepts via gamification in the form of scenario-based simulation games.

References


Highlights

- Expectations on the speed of energy transition affect investment behaviour.
- Conducted semi-structured interviews with institutional investors.
- Develop cognitive maps to illustrate the complex relationships within the system.
- Addressing issues simultaneously can amplify the effect on accelerating sustainable finance.
- Heterogeneities in investor perceptions and behaviours.