OU STEM EEES Project Proposal Form – 2024 entry

Project Title	The energy transition and stability of the global financial system
Key words	Energy transition, stranded fossil fuel assets, financial networks, complexity theory
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Is the PhD suitable for part time study?	Yes ☐ No ☒

Project Highlights:

- Join an interdisciplinary, international group of researchers working on theoretical and applied economic, mathematics and policy issues around the green energy transition.
- Gain valuable experience and expertise in network analysis, financial modelling, macroeconomic modelling and climate policy analysis.
- Contribute to the development and assessment of realistic financial and policy approaches needed for an orderly transition to net-zero.

Overview:

Tackling the climate emergency demands rapid and urgent action worldwide to reduce carbon dioxide emissions. Furthermore, emissions reductions sufficient to uphold the commitments made in the 2015 Paris Agreement will inevitably require the early retirement of existing fossil fuel assets. This implies a substantial current over-valuation of long-lived fossil fuel infrastructure and assets, including the oil and gas fields themselves. Our research has demonstrated that the readjustment of market values to correct this over-valuation could lead to a potentially rapid loss of financial value, which we have estimated to be in excess of US$1 trillion globally[1]. We have mapped these anticipated losses from the extraction companies that directly own overvalued fossil fuel assets through an equity ownership network of two million companies through to their ultimate owners[2]; individuals and governments who will bear the burden of these 'stranded assets'. Most of the risk falls on private investors, through pension-related and other financial funds and direct shareholdings in financial markets.

While these results have considerable implications for individuals, pension funds, corporates, governments and policy makers, critical unexplored issues remain around the implications for financial stability. These can only be addressed through consideration of the similarly large and complex but more opaque global lending network, where knock-on financial effects are driven through loan defaults and bankruptcies. The global impacts of a rapid stranding of assets, propagating through the debt network could, in principle, exceed those of the 2007 financial crash.

This PhD project will build synthetic debt and equity network models to explore the stability of the global financial system to shocks driven by fossil-fuel asset stranding. These theoretical networks, based on established network and complexity theories, will then be combined with real-world financial data.

The novel and revolutionary change of this PhD project will be the combination of the debt network with the equity (ownership) network. Lending data are commercially sensitive and in general are not publicly available. However, the cumulative lending and borrowing of individual companies are known. The project will construct randomized financial networks which are consistent with available global ownership and balance sheet data, including regulatory and commercial constraints.

These quasi-realistic networks will be used to trace the potential consequences of stranded asset shocks and explore strategies to minimize resulting risks to the global economy, including for instance divestment, engagement, regulatory controls, and diversification.

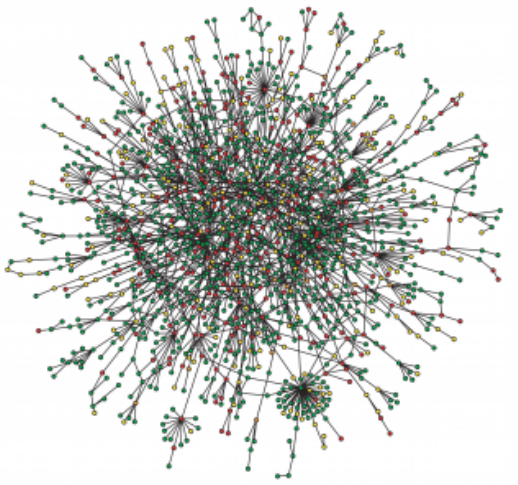

Figure 1: A scale-free network[3], analogous to the global financial system, illustrating the complex pathways by which climate-change related economic shocks would propagate through the financial system.

Methodology:

- Develop synthetic financial networks consistent with well understood mathematical, commercial and regulatory constraints and explore their input parameter space using complexity theory. Under what conditions are these networks stable and resilient?
- Combine these idealised theoretical approaches with real world company ownership and financial data to develop quasi-realistic representations of the global network of debt and equity.
- Propagate financial shocks through these randomised networks to probabilistically quantify strategies to minimise energy transition risks to global economic stability.

Training and skills:

Training will be provided and skills will be developed in macroeconomics, finance, complexity theory and mathematical modelling.

Partners and collaboration:

External collaborators will include Jean-Francois Mercure (World Bank and University of Exeter), Gregor Semieniuk (World Bank and University of Massachusetts Amherst) and Iain Weaver (University of Exeter).

Possible timeline:

Year 1 tasks: Develop synthetic financial networks and explore their resilience and stability using complexity theory.

Year 2 tasks: Develop an approach to generate randomised quasi-realistic representations of the global network of debt and equity for probabilistic analysis in Year 3.

Year 3 tasks: Design and implement large numbers of simulations of financial shock propagation to cover alternative regulatory and financing scenarios under network uncertainty.

Further reading:

1. Mercure, J.F., Salas, P., Vercoulen, P., Semieniuk, G., Lam, A., Pollitt, H., Holden, P.B., Vakilifard, N., Chewpreecha, U., Edwards, N.R. and Viñuales, J.E., 2021. Reframing incentives for climate policy action. *Nature Energy*, *6*(12), pp.1133-1143.
2. Semieniuk, G.; Holden, Philip B.; Mercure, J.-F.; Salas, P.; Pollitt, H.; Jobson, K.; Vercoulen, P.; Chewpreecha, U.; Edwards, Neil R. and Viñuales, J. E. Stranded fossil-fuel assets translate to major losses for investors in advanced economies, *Nature Climate Change*, 12(6) pp. 532-538
3. Barabási, A.L. and Bonabeau, E. (2003) Scale-Free Networks. *Scientific American*, 288, 60-69.

Further details:

Please contact philip.holden@open.ac.uk for further information and informal discussion about this project.