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BEYOND VOLUNTARY DISCLOSURE:

Why a 'market-shaping' approach to financial regulation is needed to meet the challenge of climate change

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Introduction

The financial stability implications of climate change have become a key focus for central banks and financial supervisors. The current regulatory framework for dealing with this challenge is focussed on a perceived market failure: the failure of financial market actors to publically disclose and price-in the emerging physical, liability and transition financial risks they face in the light of climate change. Underlying this approach is an implicit assumption that such risks are calculable and exogenous to the actions of market actors and regulators themselves and their interaction. In fact, climate financial risks are better thought of as endogenous and systemic, themselves generated by policy changes, technological innovation, changing consumer preferences and their complex interactions with each other, the real economy and a highly interconnected financial system. Instead of this 'market-fixing' approach embodied within the disclosure framework, it is argued that a 'market-shaping' approach to financial regulation is required. Such a policy framework assumes that market actors face uncertainty rather than calculable risk; and strives to actively steer market actors in a clear direction — towards a managed transition — but still allows space for the necessary innovation and experimentation needed to enable such a transition. Macroprudential policy is already well suited to this task but so far has not been employed to address climate financial risks by central banks and financial supervisors. It may also need to be accompanied by more proactive forms of credit guidance that requires greater fiscal-monetary coordination than is currently evident in advanced economies.

Bank of England
Source: www.bankofengland.co.uk

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The nature of climate related financial risks

It is now widely accepted that climate change can pose serious financial stability risks (Carney 2015; Gros et al 2016; TCFD 2017; Campiglio et al 2018). These include physical risks and liability risks, but also transition risks driven by changes to policy, technology and consumer behaviour that may result in a disorderly transition. Meeting a 2 degree — or, as now looks significantly more preferable, 1.5 degree[2] — temperature threshold, carbon emissions would have to decline by about 45% from 2010 levels by 2030 to reach net zero around 2050 (IPCC 2018). This requires massive structural shifts in the economy in a short time-frame. For example, according to a recent report by the International Energy Association (IEA 2017), to achieve such a transition will require $3.5 trillion in energy-sector investments on average each year until 2050 (around twice current levels of investment), nearly 95% of electricity supply to be low carbon, 70% of new cars to be electric, retrofitting of the entire building stock, and an 80% fall in the CO2 intensity of the building sector across all advanced economies.

Such a transition will have major implications for most sectors of our economies as it will require a large proportion (around 2/3rds on average across oil, gas and coal) of existing reserves of fossils fuels to remain un-extracted (McGlade and Ekins 2015; IPCC 2018). These assets will have to be written off the balance sheets of firms that own them, becoming 'stranded assets', with resulting losses in firm valuation (Dietz et al 2016). One recent study estimated that the amount of investment at risk in the fossil fuel sector alone (a measure of 'stranded assets') to be around £1.6trn assuming a shift to a 1.75-degree world by 2035 (Carbon Tracker 2018). A range of other forms of carbon-intensive infrastructure, including real estate, transport and electricity generation that depend on these stranded assets could also be negatively affected and be subject to falling valuations. Whilst the banking system in most advanced countries has only low direct exposures to firms engaged in fossil fuel extraction, it has much wider exposures to these latter sectors, not least real estate and transport (Battiston et al. 2017; Regelink et al. 2017). Some banks also have large equity exposures to institutional investors and asset managers who have more direct fossil fuel exposures (Battiston et al. 2017).

It is widely accepted that climate risks are not accurately reflected in the valuations of financial assets, nor in the lending criteria of banks and non-bank financial institutions. This stimulated the Financial Stability Board to set up the 'Task Force on Climate-related Financial Disclosures' (TCFD 2017) and more recently the creation of 'The Central Bank and Supervisor's Network for Greening the Financial System' (NGFS), currently made up of 24 financial regulatory institutions and 5 international observers across advanced and emerging market economies. Work stream 1 of the NGFS is examining the risk differential that may exist between 'green' and 'brown' assets. Work Stream 2 is focused on 'macrofinancial' policy, aiming to:

> "…develop an analytical framework for assessing climate-related risks and understand how climate-related risks can create broader systemic risk… and how authorities assess vulnerability to climate change risks in their financial stability surveillance, for example what tools they have to do this assessment: risk indicators/ monitors, stress testing, climate change mitigation scenarios, etc." (p2).

Some advanced economy central banks, such as the De Nederlandsche Bank are already investigating climate change stress-testing methodologies (Vermeulen et al. 2019), whilst others, like the Bank of England, are focussed on outlining voluntary guidelines for how private companies should disclose to their investors on climate-related related risks (PRA 2018). However, as the first NGFS (2018) progress report notes:

> "So far the integration of climate and environment-related factors into prudential supervision has been limited. Most authorities are focused on raising awareness; some are beginning to consider setting supervisory expectations." (p6).

The market fixing approach to regulation

This is striking given the urgency of the need for action now outlined in the IPCC's 1.5 degrees report. But it is in keeping with the wider approach to financial regulation that has dominated economic theory and practise since the 1980s. This essentially views competitive financial markets and the pricing system as the most efficient and welfare optimizing tool for coordinating economic activities and capital allocation.

[2]A recent report by the UN Intergovernmental Panel on Climate Change (IPCC 2018) found that keeping global warming to to a maximum of 1.5C within twelve years could significantly reduce the risks of drought, floods, extreme heat and poverty for hundreds of millions of people. The half-degree difference could also prevent the earth's corals from being completely eradicated and save many thousands of insect and other animal species from extinction.

The view has its origins in Friedriech Hayek's (1945) work on the coordination of capitalist markets and the Efficient Markets Hypothesis (Fama 1970) which argues that (stock) market prices capture all available publically available information, making them highly efficient and superior to any single market actor. The role of policy and regulation should be limited under such conditions to instances of clear 'market failure' when price discovery is being impaired.

One key reason for such supposed impairment is a lack of information about risks being publically available to market participants. This has been identified as the key challenge facing financial markets in regard to climate change. It lies at the centre of policy efforts by financial regulators to meet the challenge of climate change financial risks (Carney 2015; TCFD 2017). Disclosure of risk and transparency is also central to "Pillar III" of the international Basel III regulatory framework.

Currently, it is argued, financial corporations (including banks) are not properly calculating and disclosing their own exposures to climate risk or the preparations (or lack of) they are taking to transition their firms to a well below 2 degree economy. This lack of transparency means that climate risk is not properly 'priced in' to the market. By encouraging corporations to disclose their actual or perceived exposures and plans to deal with these exposures (e.g. via governance, risk assessment frameworks and scenario analysis), more effective price discovery can occur, 'market discipline' can be imposed and capital allocation optimised (Christophers 2017). All this, it is assumed, will thwart the potential financial stability risks of climate change and aid a transition to a low carbon economy.

The TCFD recommendations have been widely embraced, with the majority of large banks, asset managers and pension funds, credit rating agencies and accountancy firms having signed up to them (Carney 2018). However, whilst many firms have published information about their exposures, less have disclosed their views on the forward-looking financial risks they face or considered the longer term strategic resilience of their business models to the reality of the massive structural change needed to shift to a zero net carbon economy (ibid). Moreover, the evidence suggests that a voluntary approach to risk disclosure may not be sufficient to generate a step change in investment and bank lending behaviour (KPMG 2017; Christophers 2019).

Risk vs. uncertainty

One reason for this may be the classical 'first mover disadvantage' problem – it's in no firm's interest to reveal to the market information that may lead to a fall in their share price before their competitors (Lieberman and Montgomery 1988). But the bigger issue may be that it is not possible for financial firms to accurately predict the risks they face from climate transition. Risk is generally understood in economics, and financial modelling to mean 'probabilistic risk', meaning unknowable outcomes with knowable probabilities (Knight 1921). Because the probabilities are knowable, market actors can adjust their strategies and capital allocation policies to optimise their profits and resilience to shocks, even if they cannot predict eventual outcomes. If I'm going out for the day, I can look at the weather forecast and see the percentage chance of rain and choose to take an umbrella or not. The weather can be seen as an exogenous risk in that whether or not I take an umbrella does not affect the chance of rain. Fundamental to this is the efficient-market-hypothesis assumption that markets are affected by so many heterogeneous participants such that no individual market participant can move the markets. The risk manager is thus perceived as being in a "game against nature" (Danielson 2003).

But climate risk – in particular transition risk – is actually closer to being in a state of uncertainty, involving random outcomes with unknowable probabilities (Christophers 2017). This distinction was first identified by the economist Frank Knight (1921) as the actual source of profit in economies (under conditions of imperfect information) and was later developed by Keynes (1936) as a key element of his theory of macroeconomic fluctuations driven by 'animal spirits'. Transition risk can involve technological innovations (e.g. a sudden breakthrough in battery technology), changes in legislation and regulation (e.g. the rapid implementation of a carbon tax following the surprise election of a progressive political party) and changes in consumer behaviour (e.g. a shift in attitudes towards the purchase of plastics) (Chenet et al 2015). These types of risk are all inherently uncertain in terms of both their impact, their time horizon, and the means by which they will actually manifest.

Added to this is that they are typically endogenous to the system they effect rather than exogenous. For example, a policy change (e.g. a carbon tax) may occur due to a shift in consumer sentiment that makes such a tax more politically feasible or a technological breakthrough that will lower the cost of renewable energy. These types of interactions can create non-linear dynamics with high potential for positive feedback loops, covariance of risk probabilities and 'fat tails' (Thomä and Chenet 2017) creating model uncertainty. Standard statistical approaches — e.g. Value at Risk (VaR) evaluation — are unable to deal with these kinds of dynamics (Danielson 2003; Lamperti et al 2018).

Indeed, standard financial risk analysis is backward looking, usually based on less than five years of data observations and uses linear pricing techniques (Naqvi

et al. 2017). A recent survey by the Bank of England on the preparedness of UK banks for climate change found their planning horizons averaged 4 years, likely too short even to account for likely physical and liability risks (PRA 2018). Another recent study of 21 major investors found that most were still using conventional discounted-cash flow analysis to value fossil fuel firm's assets rather than examining the carbon-intensity of their resource base, making them reluctant to divest (Christophers 2019).

Further uncertainty is created by the highly interconnected nature of the modern financial system. Interlinkages among financial institutions — both banks and non-banks — can amplify both positive and negative shocks and significantly decrease the accuracy of default probabilities (Battiston et al 2012). As a result, calculations of expected losses/gains from climate policies carried out with traditional risk analysis methodologies have to be taken with great caution (Battiston et al. 2017; Balint et al 2018). For example, although European banks typically only have low direct exposures to high carbon sectors, they have exposures to pension funds and insurance companies that have larger direct exposures (Battiston et al. 2017).

In summary, we can conclude that attempting to accurately model future financial risks pertaining to a zero net carbon transition is fraught with difficulty and requires a different regulatory and supervisory approach more suited to a world of future fundamental uncertainty.

A market-shaping approach to climate risk

Under such conditions, the case for preventative or precautionary policy intervention to steer credit and investment away from 'brown' sectors or potentially stranded assets, even if the form and level of financial stability risk is unclear, becomes stronger (Cullen 2018). Or, to put it another way, it may be preferable to act now and suffer some short-term market disturbances in order to prevent much larger financial stability shocks in the future.

An outline of a 'market-shaping' approach to the challenge of the financial risks created by climate change is presented in Table 1 below. Rather than viewing the role of the regulator as primarily concerned with identifying and correcting market failures (such as imperfect information), this approach views all markets as the outcomes of the interactions between public

Table 1: Market-fixing vs Market-shaping financial regulatory frameworks to address climate change financial risks[3]

	Market fixing	Market shaping
Justification for regulatory intervention	Market or coordination failures: Imperfect information, asymmetric information, adverse selection or competition (e.g. failure to disclose climate risk)	All markets and institutions are co-created or shaped by public, private and third sectors, including regulators. Regulation should ensure markets support public purposes or missions, including, zero net carbon transition and financial stability.
Understanding of climate risk	Climate risks are exogenous shocks which can be subject to probabilistic estimation with sufficient disclosure of exposures using statistical techniques. Risk is invariant to policy intervention.	Climate risk is 'uncertain', better understood as being inherently endogenous, driven by policy action/ inaction, technological change and interaction with market actors. Characterised by non-linear dynamics, feedback loops and complexity; risks are not invariant to policy itself.
Policy emphasis	Encouraging disclosure of risk by market participants on a voluntary or compulsory basis to aid price discovery.	Favour precautionary approach to reduce chance of catastrophic losses even in the face of uncertainty; focus on whether financial system as a whole is moving in direction of mission via achievement of intermediate milestones and user engagement. Focus on portfolio of policies and interventions, and their interaction.

[3]Adapted from Kattel et al (2018)

and private actors, with the role of the state being to co-create and actively shape markets that serve wider public purpose or 'missions' (Mazzucato 2016; 2018) (in this case markets which help transition to a net zero carbon economy). Rather than the regulator playing a "game against nature", she recognises her own crucial importance in determining the outcome and direction the market will take in the future, and thus the level of financial instability that may occur. Risk is recognised as endogenous and not invariant to policy intervention. Finally, given the future is unknown and unknowable, regulatory policy should not seek a perfect solution (based on idealistic notions of price discovery) but instead favour a precautionary approach that steers the market in broadly the right direction but still enables and experimentation.

Climate related macroprudential policy

What role can central banks and financial suepervisors play in shifting from a market fixing to a market shaping approach to climate financial risk? Fortunately, a suite of policy tools has already been developed to deal with the type of uncertainty, systemic, and endogenous financial risks that characterises the climate transition: macroprudential policy.

The financial crisis of 2007-08 made clear the danger of relying on the market and financial institutions ability to judge and price risk themselves with light touch supervision by regulators. The macroprudential policy framework recognizes that market actors may be blind to certain forms of economy-wide systemic risk — including for example the build-up of mortgage debt and house prices relative to incomes — and also risks emanating from international capital flows (Galati and Moesnner 2013). Under such conditions, regulators have a duty to step in when markets were becoming overheated and risk is not properly priced in at a system level.

The objective of macroprudential policy is not to increase market transparency; rather it is usually defined as being concerned with increasing the resilience of the financial system to shocks, including rare events such as financial crises. Such events are inherently difficult to predict. Under such a scenario, the policy maker has an incentive to behave in a robust fashion, preparing for the worst case scenario. This approach favours precautionary but active policies that avoid large losses across scenarios regardless of how likely any given scenario (Bahaj and Foulis 2016). Stress tests embody this approach, providing a sense of economic outcomes if an extreme scenario emerges.

The application of this intuition to the climate transition is clear. The transition creates significant uncertainty over future financial stability and raises the risk of a rare highly catastrophic event (e.g. a financial crisis); under such conditions, the macroprudential policymaker has a strong incentive to act to insure the economy against such events, even if there are no available models to tell them the probability of such an event actually happening (Weitzman 2012).

What then might 'green' macroprudential policy look like? Most obviously, it might require banks to hold more capital against carbon-intensive ('brown') loans given the increased forward looking risk of default. The EU high level expert group on sustainable finance considered both a brown penalizing and a green supporting capital 'factor' in its final report (HLEG 2018: 67-69). Other options could involve quantitative caps on debt-financing of firms heavily dependent on carbon assets in line with a below 2 degrees temperature scenario; or some form of counter-cyclical measure, whereby capital requirements would be raised if lending to carbon-intensive sectors began to increase (Schoenmaker and van Tilburg 2016; D'Orazio and Popyan 2019). All these tools are currently in use by a number of central banks and financial regulators to guard against excessive real estate exposures and foreign capital flows (Cerutti et al 2017) although they have been used less in advanced than emerging economies.

One argument against interventions of this type is that it is the job of the government, not the independent central bank or financial supervisor, to impose policies to repress or support particular sectors of the economy[4]. The argument can be made both ways however. In the aftermath of the financial crisis, many advancwed economy central banks and supervisors were given (or asked for) greater responsibility for interventions in the mortgage market using macroprudential policy precisely because it was felt politicians, ministries of finance and the market itself would find it harder to 'Take away the Punchbowl' given political pressures. For example, in countries where the majority of voters are home-owners or would like to become so, policies that restrict mortgage credit or reduce house price growth are likely to be highly unpopular. The same issues apply to the problem of stranded assets. Politicians and ministers of finance are under enormous pressure not to regulate against large companies locked in to unsustainable industries. The lobbying power of these organisations is evident in the still enormous subsidies they receive – far outweighing the subsidies flowing in to renewable energy. There is, as with house prices, also pressure from voters. The

[4]It should be noted that macroprudential policy is only uniquely controlled by a central bank in 41 of 141 countries as of 2018 (IMF 2018).

introduction of a carbon tax for example would almost certainly push up the cost of the majority of household's energy bills.

This is not to say that governments should not also be going much further much faster to address the risks from climate change. It is rather to say, as we learned from the last global financial crisis, that financial policy makers have a duty to take systemic financial stability risk seriously, whatever sector of the economy it is coming from and not wait until the crisis arrives before taking action.

Finally, given the urgency of the climate crisis, central banks and supervisors should also be considering how they can more directly support the massive increase in sustainable finance that is required to meet the transition to a zero net carbon economy, beyond purely financial stability considerations. 'Credit guidance' — policy tools aimed at steering credit towards particular sectors of the economy — can include supply-side measures such as credit ceilings, credit quotas and interest rate ceilings which directly influence — more direclty that capital adequacy rules — the total quantity or price of credit a bank may extend over a certain period. These have fallen somewhat out of fashion in advanced economies since the 1980s with the dominance of the Efficient Markets Hypothesis. However, they were commonly used in the post-war period and in East Asia during the 1980s to support rapid economic growth, transition and industrialisation (Bezemer et al 2017) and are currently used in many emerging market economies to support green finance, including in China, India and Bangladesh (Dikau and Ryan-Collins 2016; D'Orazio and Popyan 2019). Greater cooperation between central banks and financial supervisors and other parts of government, in particular ministries of finance and industrial policy, may be necessary to achieve effective credit allocation policies of this type.

Conclusion

Achieving an orderly transition to a low or zero carbon economy over the next few decades is perhaps the greatest challenge facing financial policy makers. This challenge should not be reduced to a simple market failure due to insufficient disclosure of climate 'risk'. Policy makers should recognise the inherent uncertainty that is intrinsic to any major structural transition, not least the climate transition. Regulatory policy should seek to tilt the market in a broadly the right 'green' direction. The most obvious existing tool in central banks arsenal to better address this challenge is macroprudential policy and a shift owards a precautionary approach that encourages robust policy action now to prevent unpleasant surprises in the future.

European Central Bank (Source: Hannelore Foerster–Getty Images)

References

Bahaj, S. and Foulis, A. (2016) Macroprudential Policy Under Uncertainty. Bank of England Working Paper No. 584. http://dx.doi.org/10.2139/ssrn.2726526

Battiston, S., Gatti, D. D., Gallegati, M., Greenwald, B., & Stiglitz, J. E. (2012). Liaisons dangereuses: Increasing connectivity, risk sharing, and systemic risk. Journal of economic dynamics and control, 36(8), 1121-1141.

Battiston, S., Mandel, A., Monasterolo, I., Schütze, F. & Visentin, G. (2017) A climate stress-test of the financial system. Nature Climate Change 7, 283–288 (2017).

Campiglio, E., Dafermos, Y., Monnin, P., Ryan-Collins, J., Schotten, G., & Tanaka, M. (2018). Climate change challenges for central banks and financial regulators. Nature Climate Change, 8(6), 462.

Carbon Tracker. (2018). Mind the gap: The $1.6 trillion energy transition risk. Report. https://www.carbontracker.org/energy-firms-risk-wasting-1-6-trillion-ignoring-low-carbon-transition

Carney, M. (2015). Breaking the Tragedy of the Horizon–climate change and financial stability. Speech given at Lloyd's of London, 25th September. Bank of England.

Carney, M. (2018) Remarks at the Accounting for Sustainability Summit 2018, 21st November, Bank of England.

Cerutti, E., Claessens, S., Laeven, L., (2017) The use and effectiveness of macroprudential policies: new evidence. Journal of Financial Stability, 28, 203–224.

Chenet, H., Thomä, J., Janci, D., Dupre, S., Hubert, R., Robins, N., & Cruickshank, P. (2015). Financial risk and the transition to a low-carbon economy. Towards a carbon stress testing framework., 2 degrees investing and UNEP Inquiry in to a Sustainable Financial System, Working Paper. http://unepinquiry.org/publication/financial-risk-low-carbon

Christophers, B. (2017). Climate change and financial instability: Risk disclosure and the problematics of neoliberal governance. Annals of the American Association of Geographers, 107(5), 1108-1127.

Christophers, B. (2019) Environmental Beta or How Institutional Investors think about climate change and fossil-fuel risk, Annals of the American Association of Geographers, DOI: 10.1080/24694452.2018.1489213

Cullen, J. (2018). After 'HLEG': EU Banks, Climate Change Abatement and the Precautionary Principle. Cambridge Yearbook of European Legal Studies, 20, 61-87.

D'Orazio, P., & Popoyan, L. (2019). Fostering green investments and tackling climate-related financial risks: which role for macroprudential policies?. Ecological Economics, 160, 25-37.

Daníelson, J. (2003). On the feasibility of risk-based regulation. CESifo Economic Studies, 49(2), 157-179.

Dietz, S., Bowen, A., Dixon, C., & Gradwell, P. (2016). 'Climate value at risk'of global financial assets. Nature Climate Change, 6(7), 676

Dikau, S., Ryan-Collins, J., 2017. Green central banking in emerging market an developing country economies. New Economics Foundatiohttps://eprints.soas.ac.uk/24876/

Fama, E. F. (1970). Efficient capital markets: A review of theory and empirical work. The Journal of Finance, 25(2), 383-417.

Galati, G., & Moessner, R. (2013). Macroprudential policy–a literature review. Journal of Economic Surveys, 27(5), 846-878.

Gros, D., Lane, P., Langfield, S., Matikainen, S., Pagano, M., Schoenmaker, D., Suarez, J., (2016) Too late, too sudden: transition to a low-carbon economy and systemic risk. Technical report. European Systemic Risk Board.

Hayek, F. A. (1945). The use of knowledge in society. The American economic review, 35(4), 519-530.

IEA (2017) Perspectives for the Energy Transition - Investment Needs for a Low-Carbon Energy System. https://webstore.iea.org/perspectives-for-the-energy-transition-investment-needs-for-a-low-carbon-energy-system

IMF (2018) IMF Annual macroprudential policy survey, IMF: Washington

IPCC (2018) Global Warming of 1.5 °C, Special report of the Intergovernmental Panel on Climate Change, https://www.ipcc.ch/sr15

Kattel, R., Mazzucato, M., Ryan-Collins, J., & Sharpe, S. (2018). The economics of change: Policy and appraisal for missions, market shaping and public purpose IIPP Policy Report 2018-06. https://www.ucl.ac.uk/bartlett/public-purpose/sites/public-purpose/files/iipp-wp-2018-06.pdf

Knight, F. H. (1921/1965). Risk, uncertainty and profit, Harper and Row: New York

KPMG (2017). 'The Road Ahead: Survey of Corporate Responsibility Reporting 2017'. Available at: www.kpmg.com/crreporting

Lieberman, M. B., & Montgomery, D. B. (1988). First-mover advantages. Strategic management journal, 9(S1), 41-58.

Mazzucato M., (2016) From Market Fixing to Market-Creating: A new framework for innovation policy, special issue of Industry and Innovation: Innovation policy – can it make a difference?, Vol. 23, No. 02, 140-156

Mazzucato, M. (2018). Mission-oriented innovation policies: challenges and opportunities. Industrial and Corporate Change, 27(5), 803-815.

McGlade, C., & Ekins, P. (2015). The geographical distribution of fossil fuels unused when limiting global warming to 2 C. Nature, 517(7533), 187.

Naqvi, N., Burke, B., Hector, S., Jamison, T. and Dupré, S (2017) All swans are black in the dark. Report. 2 degrees investing initiative and Generation Foundation.

Prudential Regulation Authority (PRA) (2018) Transition in thinking: The impact of climate change on the UK banking sector, September 2018, Bank of England. https://www.bankofengland.co.uk/prudential-regulation/publication/2018/transition-in-thinking-the-impact-of-climate-change-on-the-uk-banking-sector

Regelink, M., van Reinders, H., van der Viel, I. & Vleeschhouwer, M. (2017) Waterproof: an exploration of climate related financial risks. De Nederlandsche Bank.

Schoenmaker, D., Van Tilburg, R., 2016. What role for financial supervisors in addressing environmental risks? Comparative Economic Studies. 58 (3), 317–334.

TCFD (2017). Final Report: Recommendations of the Task Force on Climate-related Financial Disclosures, https://www.fsb-tcfd.org/publications/final-recommendations-report/

Thomä, J. & Chenet, H. (2017) Transition risks and market failure: a theoretical discourse on why financial models and economic agents may misprice risk related to the transition to a low-carbon economy, Journal of Sustainable Finance & Investment, 7:1, 82-98

Vermeulen, R, Schets, E., Lohuis, M, Kölbl, B., Jansen, D-J, and and Heeringa, W., (2019) The Heat is on: A framework measuring financial stress under disruptive energy transition scenarios, De Nederlandsche Bank Working Paper No.625 / February 2019, https://www.dnb.nl/en/binaries/Working%20paper%20No%2E%20625_tcm47-382291.pdf

Weitzman, M. L. (2012). GHG targets as insurance against catastrophic climate damages. Journal of Public Economic Theory, 14(2), 221-244.

Further information

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