STRANDED ASSETS PROGRAMME

SMITH SCHOOL OF ENTERPRISE AND THE ENVIRONMENT

UNIVERSITY OF OXFORD

Greening China's Financial Markets: The Risks and Opportunities of Stranded Assets

Briefing Paper

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Inquiry: Design of a Sustainable Financial System

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About the Stranded Assets Programme

The Stranded Assets Programme at the University of Oxford's Smith School of Enterprise and the Environment was established in 2012 to understand environment-related risks driving asset stranding in different sectors and systemically. We research the materiality of environment-related risks over time, how different risks might be interrelated, and the potential impacts of stranded assets on investors, businesses, regulators, and policymakers. We also work with partners to develop strategies to manage the consequences of environment-related risks and stranded assets.

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About the UNEP Inquiry

The Inquiry into the Design of a Sustainable Financial System has been initiated by the United Nations Environment Programme (UNEP) to advance design options that would deliver a step change in the financial system's effectiveness in mobilizing capital towards a green and inclusive economy.

Established in January 2014, it will publish its final report in the second half of 2015. More information on the Inquiry can be found here: http://www.unep.org/greeneconomy/financialinquiry

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Briefing Paper

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The views expressed in this paper represent those of the author(s) and do not necessarily represent those of the host institutions or funders.

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Executive Summary

The rise and fall of different technologies, products, and businesses is central to rising productivity in healthy, well-functioning markets. This process can result in 'stranded assets', assets that have suffered from unanticipated or premature write-downs, devaluations, or conversion to liabilities.[1] Stranded assets are therefore a regular and necessary feature of dynamic economic systems, a phenomenon inherent in the 'creative destruction'[2] of economic growth, transformation, and innovation.

Over the course of the last two decades, the issues surrounding technological innovation, investor behaviour, and business resilience have become magnified in the context of environmental change. The advent of international climate policy and movement towards pricing environmental externalities has raised concerns about the 'lock-in' of carbon-intensive technologies[3]. This has helped to bring forward the issue of stranded assets as a sustainability concern beyond regulatory action on competition policy.

Evidence shows that asset values have been impacted across a wide range of sectors and geographies as local and global environmental boundaries are breached. The drivers range from physical climate change and natural capital degradation, through to new environmental regulations, developments in clean energy technology, resource constraints, evolving social norms, and litigation.[4] These current and emerging risks related to the environment could represent a major discontinuity, able to profoundly alter asset values across a wide range of sectors.[5] For example, air pollution and water scarcity in China threatens coal-fired power generation, which has changed coal demand and affected global coal prices;[6] the shale gas revolution in the US has put downward pressure on coal prices in Europe, stranding new high-efficiency gas plants;[7] and the fossil fuel divestment campaign threatens to erode the social licence of some targeted companies and could increase their cost of capital.[8]

China's strategic decision to move away from a high pollution and high resource intensive economy and build an 'eco-civilisation' will clearly have implications both for existing assets, as well as the trajectory of future capital investment. This will be problematic for some firms and sectors, but need not hinder China's economic development and could actually work to support China's multiple, inter-locking objectives of addressing inequality, ensuring sustainable growth, increasing domestic consumption, and improving social infrastructure.

One opportunity is to secure an optimal rate of asset stranding given China's level of economic development, targeted rate of economic growth, and sustainability concerns. Too little asset turnover could leave China with insufficiently productive assets far from technological frontiers, while too much could result in unmanageable losses for companies and financial institutions, as well as challenging social issues due to job losses and displaced industries. While leaving polluting, inefficient assets in place will undermine sustainability and long-term growth.

Another dimension related to this is the avoidance of lock-in. China should avoid investing in technologies and infrastructure that might quickly become outdated or inappropriate from a societal perspective. An example could be new build sub-critical coal-fired power stations given ever-increasing concerns over air pollution and water scarcity, as well as the availability of cost competitive alternatives. Lock-in of this kind is expensive for society as a whole and ties up capital that could be deployed productively elsewhere.

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[1] Caldecott, "Stranded Assets Programme".
[2] A term popularised by Schumpeter, see Reinert and Reinert, 2006.
[3] Unruh, 2000.
[4] Caldecott and Mcdaniels, 2014a.
[5] Caldecott, "Stranded Assets Programme".
[6] Caldecott, Tilbury and Ma, 2013a.
[7] Caldecott and Mcdaniels, 2014b.
[8] Ansar, Caldecott and Tilbury, 2013.

The profile of a transition pathway is also important. The value lost through asset stranding should ideally be more than offset by new value creation in other areas and this should happen smoothly over time. Without a smooth and gradual profile, it will be harder to secure political and societal support. An analysis of stranded assets can help to reveal the potential profile of a transition pathway and additionally, help to identify winners and losers across sectors. Identifying the groups affected, particularly those negatively impacted, can allow for the provision of targeted transitional help – another way of ensuring support is sustained throughout a transition that might involve painful losses for some firms.

In terms of the financial system, better understanding the materiality of environment-related risks driving stranded assets and the levels of exposure in different parts of the financial system will help regulators manage scenarios that could result in financial instability. Within financial institutions, revealing and better pricing environment-related risks will improve risk management and hedging, potentially improving system resilience as well as portfolio performance. Higher risk premia for assets more exposed to environment-related risks may also have the added benefit of shifting capital allocations away from sectors that could be considered environmentally unsustainable, and towards assets more in-line with China's vision for a cleaner and more sustainable economy.

To encourage financial institutions to take a precautionary approach, stress tests required by regulators could be extended to environment-related risks driving stranded assets. For example, a carbon stress test could involve assessing the impact on portfolios of the rapid introduction of the effective carbon pricing.[9] Additionally, given that environment-related risks are likely to affect underlying asset bases of financial institutions (to the degree that they lend to clients in vulnerable/high risk industries) there could be merit in higher capital requirements for assets with greater levels of exposure to such risks.

In addition to the implications for financial markets, environment-related risks and stranded assets will impact company strategy. Companies exposed to environment-related risk factors or dependent on clients exposed to these risks may need to adapt their business models, and firms better able to manage emerging environment-related risks could secure significant competitive advantages over time.

[9] See Kapoor, Oksnes and Hogarth, 2011.

1. Stranded assets and the transition to a green economy

The rise and fall of different technologies, products, and businesses is central to rising productivity in healthy, well-functioning markets. This process can result in 'stranded assets', assets that have suffered from unanticipated or premature write-downs, devaluations, or conversion to liabilities.[10] Stranded assets are therefore a regular and necessary feature of dynamic economic systems, a phenomenon inherent in the 'creative destruction'[11] of economic growth, transformation, and innovation. This dynamic process poses risks to individuals and firms, and due to macroeconomic dimensions, may have sectoral or potentially systemic implications.

Regulatory changes are one driver of asset stranding: in regulated markets policymakers and regulators have the ability to change the 'rules of the game' and to quickly create winners and losers, with significant implications for invested capital. This has proven to be a significant issue in the case of the electricity sector, where large scale, capital-intensive infrastructure investments with long operational life expectancies are often affected by such changes. The introduction of competition into US and EU utilities sectors in the 1990s presented significant challenges to regulatory economic theory.[12] Whether or not sunk costs should be considered legitimately 'stranded' proved important in evaluating whether or not it was economically or socially desirable to compensate firms for unrecoverable investments. Regulatory developments following the introduction of competition policy – including renewable energy deployment and climate policy – have taken the issue of stranded assets in the context of the power sector beyond these initial questions.

Over the course of the last two decades, the issues surrounding technological innovation, investor behaviour, and business resilience have become magnified in the context of environmental change. The advent of international climate policy and movement towards pricing environmental externalities has raised concerns about the 'lock-in' of carbon-intensive technologies[13]. This has helped to bring forward the issue of stranded assets as a sustainability concern beyond regulatory action on competition policy. Asset values have been impacted across a wide range of sectors and geographies as local and global environmental boundaries are breached. The drivers range from physical climate change and natural capital degradation, through to new environmental regulations, developments in clean energy technology, resource constraints, evolving social norms, and litigation.[14] Current and emerging risks related to the environment could represent a major discontinuity, able to profoundly alter asset values across a wide range of sectors.[15] For example, air pollution and water scarcity in China threatens coal-fired power generation, which has changed coal demand and affected global coal prices;[16] the shale gas revolution in the US has put downward pressure on coal prices in Europe, stranding new high-efficiency gas plants;[17] and the fossil fuel divestment campaign threatens to erode the social licence of some targeted companies and could increase their cost of capital.[18]

These risk factors and others related to the environment could have a significant impact on the ability of different asset classes to generate value in the future, including physical, financial, natural, and intangible assets.[19] The prospect of stranded assets as a result has recently emerged as an area of concern and this has been flagged by academic institutions, financial institutions, and advocacy organisations.[20]

[10] Caldecott, "Stranded Assets Programme".
[11] A term popularised by Schumpeter, see Reinert and Reinert, 2006.
[12] Cearley and Mckinzie, 1994; Michaels, 1994; Baumol and Sidak, 1995; and Kolbe and Tye, 1996.
[13] Unruh, 2000.
[14] Caldecott and Mcdaniels, 2014a.
[15] Caldecott, "Stranded Assets Programme".
[16] Caldecott, Tilbury and Ma, 2013a.
[17] Caldecott and Mcdaniels, 2014b.
[18] Ansar, Caldecott and Tilbury, 2013.
[19] Caldecott "Stranded Assets Programme".
[20] For example: Caldecott, 2011; Caldecott, "Stranded Assets Programme"; Carbon Tracker Initiative, 2011; Generation Investment Management, 2012, 2013; HSBC, 2012, 2013; Mckibben, 2011; Standard & Poor's, 2013.

Beyond direct financial losses, stranded assets may have implications for decision-making as well. As the nascent discourse has demonstrated, the real and potential impacts of environment-related risks are starting to be noticed and this could have long term implications for asset allocation decisions and risk management – all the way from the individual and the firm through to fund managers, asset owners, and governments.

Stranded assets, unburnable carbon: the development of carbon asset risk

From the late 1980s and accelerating rapidly from 2000, individuals and organisations working on climate and sustainability issues began to acknowledge the possibility that environmental policy and regulation could negatively the influence value or profitability of fossil fuel companies to the point that they could become impaired.[21] With the concept of a global 'carbon budget'[22] – the 1 trillion tonnes of cumulative atmospheric CO2 emissions allowable for 2 degrees of global warming – there was a way to determine when this might happen. When the amount of fossil fuels combusted, plus the amount of carbon accounted for in reserves yet to be burned exceeded the carbon budget, either the climate or the value of fossil fuel reserves along with associated high carbon infrastructure would have to give.

This largely academic discussion has risen up the investment and policy agenda, particularly following the 2011 publication of the report by the Carbon Tracker Initiative (2011) entitled, *Unburnable Carbon: are the world's financial markets carrying a carbon bubble?*, the findings of which were popularised by the environmentalist Bill McKibben.[23] The concept of 'unburnable carbon'[24] – the proportion of fossil-fuel reserves that must remain in the ground in order to stay within the carbon budget – quantified the disconnect between the value of the listed equity of global energy firms and their potential commercialisation under a strict carbon constraint introduced by climate policy.

The idea that 'unburnable' fossil fuel reserves could become stranded assets has been taken up by a number of high profile actors and helped spark a significant discussion on the risk of investing in fossil fuels.[25] For example, HSBC research concluded in 2012 that a global peak in coal consumption in 2020 – a necessary condition for the transition to a low-carbon economy – would devalue existing share prices of coal assets on the London Stock Exchange by 44%.[26] Though the thesis of a multi-trillion dollar 'carbon bubble' with potentially systemic implications for the global economy has inspired divergent responses – from qualified support to outright opposition[27] – it has spurred the development of the fossil fuel divestment campaign, as well as high-level investor engagement with major listed fossil fuel companies.[28]

Towards a spectrum of environment-related risk

Recent developments illustrate that other environment-related risks and not just those related to an atmospheric carbon constraint enforced by policy can have a significant impact on assets today, and these are likely to increase in significance over time. Caldecott et al. (2013) propose a typology for these different environment-related risks that could cause stranded assets, which are set out below.[29] The risks have been grouped together as 'environment-related' as each is connected with environmental protection and environmental change, and there are potential correlations and connections between each set of risks – though the extent of these interdependencies is yet to be determined and is an important area for future research.

21 IPCC, 2001; IEA, 2008.
22 Krause, Backh and Koomey, 1989.
23 Mckibben, 2011.
24 Carbon Tracker Initiative, 2011.
25 Ansar et al., 2013.
26 HSBC, 2012.
27 Climate Change Capital, 2012; Environmental Audit Committee, 2014a; King, 2012; Weitzig et al., 2014.
28 Ansar et al., 2013.
29 Caldecott, Howarth and McSharry, 2013; Caldecott, "Stranded Assets Programme".

Figure 1: Typology of Environment-related Risk[30]

SET	SUBSET
Environmental change	Climate change; natural capital depletion and degradation; biodiversity loss and decreasing species richness; air, land, and water contamination; habitat loss; and freshwater availability.
Resource landscapes	Price and availability of different resources such as oil, gas, coal and other minerals and metals. E.g. shale gas revolution, phosphate availability, and rare earth metals.
Government regulations	Carbon pricing (via taxes and trading schemes); subsidy regimes (e.g. for fossil fuels and renewables); air pollution regulation; voluntary and compulsory disclosure requirements; changing liability regimes and stricter license conditions for operation; the 'carbon bubble' and international climate policy.
Technological change	Falling clean technology costs (e.g. solar PV, onshore wind); disruptive technologies; GMO; and electric vehicles.
Social norms and consumer behaviour	Fossil fuel divestment campaign; product labelling and certification schemes; and changing consumer preferences.
Litigation and statutory interpretations	Carbon liability; litigation; damages; and changes in the way existing laws are applied or interpreted.

Source: Based on Caldecott et al., 2013

There are many examples of assets affected by the above environment-related risks, either separately or from a combination of risks being present simultaneously.[31] Evidence from different domains, such as the insurance sector[32] and studies on specific risks such as the emergence of climate regulation,[33] suggest that these risks are growing in significance and the speed at which they are emerging is accelerating.

There are a number of different reasons why investors, firms, regulators, and policymakers may want to explore stranded assets from an environment-related risk perspective:

Political economy: environment-related risks are likely to create winners and losers across sectors, and may do so in potentially unexpected ways. Understanding how firms may respond to stranded assets in terms of corporate strategy may be useful in examining potential implications for climate policy and environmental regulation.

Value at risk: the size of potential value at risk and risk at a variety of levels (e.g. investments, business models, development strategies), sectors, and geographies is significant.

Socially inefficient asset stranding: lock-in and inefficient transitions can be undesirable from a societal and policy perspective. Optimising the process of transition to a more sustainable global economy, (e.g. smooth profile of value destruction being offset by value creation) is an important point of analysis in the debate around stranded assets.

[30] Based on Caldecott, Howarth and McSharry, 2013.
[31] Caldecott, Tilbury and Carey, 2014.
[32] Munich RE, 2014.
[33] Nachmany et al., 2014.

Risk management and hedging: understanding potential risks may facilitate improved risk management and hedging capabilities of firms, which is of importance for asset owners and fund managers. More clearly understanding the role of stranded assets in firm value may bolster portfolio resilience under certain scenarios.

Business strategy: companies exposed to these risk factors or dependent on other companies exposed may need to consider implications for business models.

A critical issue for policymakers and financial institutions is to understand how a spectrum of factors ranging from local to international environmental regulation, the nexus of physical resource stress, as well as technological innovation and shifts in societal expectations could converge to imperil valuable assets.

2. International experience of stranded assets

Firms in different sectors may experience significant competitiveness impacts from environment-related risks, either from direct impacts on their asset base or from impacts on the asset bases of their competitors. Asset stranding may affect firm value in different ways. Assets held by firms can include capital stock investments (such as extraction, production, and transport infrastructure) as well as current asset inventory (such as oil or mineral reserves, agricultural land, or natural resource inputs) that determine how firms may be valued. In this context, stranded assets may have unpredictable and counter-intuitive implications for the value of firms exposed to environment-related risks. This section summarises five examples of environment-related risks stranding or threatening to strand assets in different sectors.

Case Study 1: Coal assets in the USA

On 2nd June 2014, the EPA unveiled a new proposal to reduce CO_2 emissions from US power plants by 30% from their 2005 level by 2030. The proposal gives targets on a state-by-state basis, allowing each state to choose how to meet them. Although current emissions are already around 15% below 2005 levels, the proposal is expected to have a significant impact on the US energy industry, particularly coal as the US coal fleet currently produces 74% of power plant US emissions,[34] but only 39% of US electricity.[35] Even before the EPA proposals, however, coal assets had started to become uneconomical for several reasons.

In 2013, Brayton Point Station, which is one of the leading sources of emissions in Massachusetts, was announced for closure in 2017, in spite of a determination by ISO New England (an independent Regional Transmissions Organisation that oversees the operation of New England's bulk electric power system and transmission lines) that it is needed to help meet demand.[36] Its previous owner had spent $1.1bn to install new pollution controls, but it was predicted to lose over $3m in 2014, mainly because of low natural gas prices, showing how, even with major capital investments, many old coal fired plants have become uneconomical.[37] This early retirement is part of a wider trend in the US. Between 2009 and 2013, 20.8 GW of coal-fired power plants, 6.2% of the 2009 US coal fleet, were retired and another 30.7 GW were 'slated' for retirement, with most estimates indicating that there will be further coal retirements of between 25 to 100 GW by 2020.[38] The EIA, for instance, predicts 60 GW of coal retired by 2020 and a study by Fleischman et al (2013) indicates that 59 GW of coal units are 'ripe for retirement', in addition to the 28 already announced for retirement before 2025. One study by Synapse Energy Economics (2013) gives a significantly higher figure, of 228 to 295 GW as vulnerable having considered a wider range of costs including cooling water, water effluent controls, and coal ash.[39]

One of the principal reasons for this stranding of US coal assets, has been the shale gas boom which has provided a cheaper and cleaner alternative to coal. A BNEF report predicts that US natural gas prices will remain low (less than $5 per MMBtu) until 2024, forecasting that the US fleet of gas-fired power stations will rise to 134 GW by 2030.[40] A further challenge to coal comes from the advent of increasingly attractive renewables: wind costs have fallen by about 80% in the last three decades[41] and the costs of solar photovoltaics (PV) have also been falling rapidly because of a steep drop in manufacturing costs. As a result, PV capacity in the US has

34 EIA, 2013, Table 12.6.
35 EIA, 2014, Table 7.2a.
36 See ISO New England, 2014 .
37 Fleischman et al., 2013.
38 Ibid.
39 Knight et al., 2013.
40 BNEF, 2013.
41 Fleischman et al., 2013.

reached 8.9 GW[42] and rooftop solar PV installations are predicted to grow to a 10% share of the US capacity mix by 2030.[43]

The Obama administration has said that it still expects 30% of US electricity to come from coal in 2030[44]. However, significant investment has already been stranded, and the coal industry has recognized that even more is at risk: the Chairman and CEO of American Electric Nick Atkins admitted in May 2014 that 'it's a critical issue for us not to strand all that investment that we made and secondly to make sure the grid can operate in a reliable fashion through this transition.'[45]

Case Study 2: European power sector transformations and CCGTs[46]

Over the course of 2013, a large number of recently built, high-efficiency combined cycle gas-turbine (CCGT) power plants across the EU were prematurely closed or mothballed, while coal retained or gained market share. Motivated by the combined effects of decreased electricity demand from the financial crisis, merit order effects of renewable energy implementation on capacity needs and price volatility, lacking a carbon price incentive, and cheap coal from the US shale boom, gas-fired power plants profits fell to the point of being uneconomic in comparison to coal power.

Responding to poor market conditions, utilities have been rapidly mothballing CCGTs. Estimates suggest 51 GW of the EU's generation capacity is currently mothballed and 60% of EU gas-fired capacity not recovering fixed costs, possibly facing closure within three years.[47] Importantly, a significant amount of gas capacity recently mothballed has been built or acquired over last 10 years: new, high efficiency units – such as Statkraft's 430 MW Knapsack 2 plant, and Vattenfall's 1300 MW Magnum unit – have been immediately mothballed upon commissioning.[48]

Mothballing actions have resulted in significant write-downs on gas-fired power assets. The top 16 EU utilities reported €14.6bn in impairments on generation assets over the course of 2010-2012[49], while notable actions in 2013 – including GDF Suez' impairment of €2bn and Vattenfall impairment of €1.7bn have stemmed mostly from EU gas assets. Recent instances of stranding have exacerbated downward trends in total utility equity and market capitalization since the financial crisis, as evidenced by the MSCI Utilities index loss of €500bn since 2008.[50] Along with credit downgrades and the revision of dividends to preserve balance sheets, major utilities have significantly curtailed planned capacity investments, contributing to increasing fears about system security and the risk of blackouts in different EU countries.

Although it remains unclear what the long-term impacts of stranded CCGTs will be on EU energy markets, recent proposals to develop capacity mechanisms make clear the importance of stranded assets on both utility behaviour and policy-making. The cascading impacts of stranded CCGTs assets on firm balance sheets, shareholder returns, credit, and overall company value is a potent reminder of how rapidly a diverse range of sustainability-related risk factors – including technological innovation (shale gas), social norms (regarding nuclear energy), and regulation (renewable energy targets and air pollution regulations) – may result in unexpected outcomes.

[42] Fleischman et al., 2013.
[43] BNEF, 2013.
[44] Jopson, 2014.
[45] quoted by Chegiak and Polson, 2014.
[46] Based on Caldecott and McDaniels, 2014b.
[47] IHS CERA, 2013.
[48] Ibid.
[49] EY, 2013.
[50] Economist, 2013.

Case Study 3: Carbon Supply Cost Curves

The upstream oil industry[51] could be facing a dual challenge: a 'carbon crunch' driven by actual and potential climate regulation and a 'cost squeeze' driven by a shift toward expensive and difficult-to-extract reserves, increased technical risks, and renewed geopolitical risks. These factors could lead to the stranding of investment in the development of new reserves.

In order to have an 80% chance of limiting global warming to 2°C, the Carbon Tracker Initiative (CTI) estimate that, with assumptions about the reduction of non-CO_2 emissions, the global 'carbon budget' through 2050 is 900 $GtCO_2$.[52] If oil is kept at its current share of global emissions, around 40%, this implies an oil-specific budget of 360 $GtCO_2$. CTI estimates that oil reserves are capable of supplying 1.8 times this by 2050[53] and argue that if a global climate change agreement is reached that is likely to result in a substantial proportion of these reserves becoming stranded assets.

Meanwhile, production costs and capital expenditure have been rising rapidly. Since 2000, the oil industry's investments have risen by 180%, with global oil supply increasing by just 14%.[54] An EY study of 75 oil companies found that global capex increased by 13% in 2012, while combined profits fell by 16%.[55] This reflects the increase in production of 'unconventional' oil, such as shale oil, tight liquids, and oil sands, as well as a shift toward deep-water projects in the production of 'conventional' oil. Even lower-cost projects are seeing higher levels of technical and geopolitical risk. Goldman Sachs identify five criteria for technical risk: water depth, environment/geography/climate, technology dependence, geological issues, and infrastructure dependence. They find technical risk in their database of new projects will 'rise to never-before-seen levels of risk'.[56] Furthermore, through 2025, oil companies have $215bn of capex planned in countries with geopolitical risk that Goldman Sachs rates as 'high' or 'very high'.[57]

The 2014 CTI report analyses this cost squeeze using Carbon Supply Cost Curves which plot cumulative oil production against lifecycle emissions. This allows them to analyse projects using the break even oil price (BEOP): the oil price at which an asset yields a net present value of zero, with a 10% internal return. CTI are then able to estimate key BEOP levels by combining demand projections with global supply curves and examine the marginal BEOP of oil under different demand scenarios.[58] Projects that have a BEOP over $80/bbl ($95/bbl+ market price) are most vulnerable to stranding in a low carbon demand scenario.[59] The report also examines the categories and locations of projects, to allow investors to better understand their exposure to risk.[60]

The oil majors' own projections of oil demand are higher than the low carbon demand scenarios suggested by CTI, but there are a range of emissions scenarios that should be considered and the assumptions underlying demand projections should be stress tested. For instance, Mark Lewis, of financial services company Kepler Chevron, criticises ExxonMobil's recent report 'Energy and carbon – managing the risks' as too dismissive of the possibility of coordinated global policy and too binary in the assessment of the climate-policy risks faced.[61]

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51 'Oil' includes crude oil, condensates and NGLs here: see Carbon Tracker Initiative 2014, p. 26.
52 Carbon Tracker Initiative, 2013, p. 4.
53 Carbon Tracker Initiative, 2014, p. 32.
54 Ahmed, 2014.
55 Chazan and Crooks, 2013.
56 Goldman Sachs, 2013, p. 120-123.
57 Goldman Sachs, 2013, p. 126.
58 Carbon Tracker Initiative, 2014, p. 16.
59 Ibid, p. 46.
60 Ibid, p. 39.
61 Lewis, 2014, p. 4-5.

Case Study 4: Agricultural commodity value chains[62]

The recent boom in agricultural commodity prices has sparked interest in agriculture as an asset class. This has contributed to an increase in the value of underlying assets such as farmland, and seen capital flow into much needed productivity-enhancing investments. However, this boom has coincided with unprecedented levels of environment-related risk in agricultural systems.

The report 'Stranded Assets in Agriculture'[63] maps out a typology of environment-related risks that could strand assets along the agricultural supply chain and completes an assessment of each. The report also provides a high-level value at risk analysis quantifying environment-related risk. As the report makes clear, environment-related risks in the agriculture sector are currently insufficiently assessed and incorporated into investment decisions. The absence or inadequacy of regional, national, and trans-national governance arrangements intended to manage these risks and address collective action problems further compound these problems.

There are a range of environment-related risks that may impact different agricultural assets. Weather variability is the most important driver of both yield and resilience risk for crop-based agriculture, and can have significant consequences for animal agriculture. Degradation of natural capital stocks, including land and soil resources, biodiversity loss, and associated provisioning ecosystem services, may significantly affect the value of physical assets such as farmlands. An increasing prevalence of agricultural diseases, pest species, ecosystem fragility, and the geographic distribution of these risks, may also negatively affect value in unexpected ways.

The value of different agricultural assets may also be negatively affected by economic drivers, including the price and availability of agricultural inputs (e.g. phosphate-based fertilisers) and the proliferation and maintenance of water infrastructure, as well as political drivers such as property rights regimes, land use regulations, trade policy, and industrial policies. Changing social norms may increase exposure of firms with unsustainable assets and supply chain practices to stigmatization and increasing costs. For example, eco-labelling, voluntary standards, and international regulation may represent competitiveness impacts for some firms, and opportunities for others.

At a macro-level, assets at risk from physical impacts include high fixed or sunk costs assets of low liquidity closely linked to land value, including natural assets (farmlands) and physical assets (including multi-year crops, processing, and transport infrastructure). Irrigated crops and related infrastructure may prove to especially vulnerable in areas relying heavily on seasonal water availability.

Case Study 5: Social norms and the divestment campaign[64]

Divestment is a socially motivated activity of private wealth owners, either individuals or groups, such as university endowments, public pension funds, or their appointed asset managers.[65] Owners can decide to withhold their capital—for example, by selling stock market-listed shares, private equities or debt—from firms engaged in a reprehensible activity. Tobacco, munitions, corporations in apartheid South Africa, provision of adult services, and gaming have all been subject to divestment campaigns in the 20th century. The fossil fuel divestment campaign, a recent and extant social phenomenon, is one such campaign that could affect the value of fossil fuel assets. Ansar et al. (2013) tests whether the divestment campaign could affect fossil fuel assets and if so, how, to what extent, and over which time horizons.

[62] Based on Caldecott, Howarth and McSharry, 2013.
[63] Ibid.
[64] Based on Ansar et al., 2013.
[65] Kaempfer, Lehman and Lowenberg, 1987.

Worried about the impact of climate change, civic group 350.org launched a campaign in 2012 encouraging 'institutions to immediately freeze any new investment in fossil fuel companies, and divest from direct ownership and any commingled funds that include fossil fuel public equities and corporate bonds within 5 years'.[66] 350.org is a not-for-profit organisation that aims to address climate change through online campaigns, grassroots organisation and mass public actions.

The analysis conducted by Ansar et al. (2013) shows that the direct impacts of divestment on fossil fuel equity are likely to be limited – the maximum amount of capital that could be divested from fossil fuel companies represents a small amount of funds, and share prices are unlikely to suffer significant declines as other alternative investors step in.[67] Potential direct impacts on coal are more likely than oil and gas firms, as alternative investors may not be as readily available.

Although direct impacts may be insignificant in the short-term, the stigmatization of different energy firms with especially poor environmental performance and risk management efforts are likely to have much more significant impacts over the long term. Importantly, different classes of firms – including pure-play coal miners – may be especially vulnerable to the impacts of increasing public awareness and stigmatization, including impacts on trading multiples.

Increasing shareholder pressure to manage environment-related risks look set to become more important. In 2013 there were a number of notable shareholder actions on high-carbon assets, including Storebrand's divestment from 24 coal and oil sands firms and SWIP's divestment from pure-play coal producers,[68] as well as increasing pressure for investor coalitions on global energy firms to disclose carbon-related risks.[69]

[66] Fossil Free, 2013.
[67] Ansar et al., 2013.
[68] Riseborough and Biesheuvel, 2013.
[69] Ceres, 2013.

3. Financial market responses

The prospect of stranded assets induced by environment-related risks will prompt a range of responses from policymakers, regulators, and financial institutions alike. The financial system implications of stranded assets are significant and this section provides a non-exhaustive overview of some of the responses that have taken place or might develop in the future.

3.1 Public policy and regulation

There has been a wide range of research on the micro and macro implications of various public policy and regulatory responses to different environment-related risks. However, this work has not been focused on the financial system. Here we focus specifically on recent research and analysis pertinent to finance, banking, insurance, and investment in order to derive specific implications for the financial system.

3.1.1 Monetary policy responses

To date there is little evidence suggesting that governments implement monetary policy actions explicitly in response to environment-related risks, though governments have implemented monetary policy actions in response to changes in the value of natural capital stocks (i.e. discoveries or depletion of resource wealth), losses of natural capital (i.e. natural catastrophe events), and changes in the value of market goods and services predicated upon natural capital stocks and flows (i.e. price volatility within international commodity markets).

Much of the analysis in this area relates to the management of natural resource extraction rents, including energy resource discoveries[70] and the management of long-term resource depletion.[71] Instead of expanding on this discussion, here we focus on recent findings from analysis of monetary policy responses to i) natural catastrophe events and ii) commodity price volatility. We concentrate on these areas of research as these processes may serve as partial proxies for the impacts of environment-related risks.

i) Monetary policy responses to natural catastrophe events

Natural catastrophe events (NCEs) have major direct and indirect costs at the macroeconomic level[72] and within different sectors across the economy.[73] These costs may constitute significant issues for public finance and debt, as NCEs impacts necessitate increased government spending concurrent with a decrease in fiscal revenues.[74] Monetary responses to NCEs are often aimed at stimulating the economy in advance of a long-term economic slowdown; for example the Thai central bank reduced interest rates from 3.5 to 3.25% in anticipation of significant output declines from flood damage in 2011.[75] Governments implement monetary responses to NCEs in order to stabilise the economy and mitigate losses from environmental damage, but there has been less focus on the use of such instruments to manage interrupted flows of natural capital to the economy.

Beyond monetary policy there is an increasing volume of analysis of broader macroeconomic and fiscal policy responses to NCEs and physical climate impacts, with studies examining the fiscal impacts of Hurricane Sandy,[76] Caribbean hurricanes,[77] floods,[78] and other catastrophes. Many different fiscal policy tools and

[70] Wills, 2013.
[71] Studies include Leigh and Olters, 2006; Collier et al., 2010; and Cologni and Manera, 2013.
[72] Hallegatte and Przyluski, 2010.
[73] Loayza et al., 2012.
[74] Melecky and Raddatz, 2014.
[75] Yuvejwattana, 2011.
[76] Mantell et al., 2013.
[77] Ouattara and Strobl, 2013.

combinations of responses to NCEs have been implemented, with varying effects on macroeconomic growth and financial stability. While these lessons are pertinent to implications for financial stability stemming from responses to natural capital degradation, many dimensions of such policies relate to broader macroeconomic issues and are thus hard to disaggregate as specific actions with environmental objectives.

ii) Monetary policy responses to commodity market volatility

Governments may introduce monetary policy responses to commodity market volatility based upon either changes in the value of export-based capital inflows or exposure of domestic consumers to significant shifts in the CPI, leading to inflation. Changes in values of exports of primary natural commodities (such as oil, agricultural products, or other natural resources) can significantly affect capital inflows. Inflationary impacts from increased prices for exports can be exacerbated by pro-cyclicality of bank lending, increasing risk of systemic negative consequences during major price downturns.[79] For example, oil-based capital inflows and loose monetary policy in Nigeria led to a severe credit-based financial crisis. Following a cumulative real growth in private sector credit of 235% over 2006–08, the fall in oil prices stemming from the 2008 financial crisis led to a rapid increase in non-performing loans, bank failures, and eventual monetary policy actions by the Central Bank of Nigeria (Masson, 2014).[80]

3.1.2 Requiring preventive action by financial institutions

Stress tests are used by regulators to assess the resilience of financial institutions in the face of 'unlikely but plausible' scenarios. This approach could be extended to environment-related risks to encourage banks to take a precautionary approach to climate, energy, water and other resource factors. For example, a carbon stress test could involve assessing the impact on portfolios of the rapid introduction of the effective carbon pricing.[81] Importantly, the price of carbon could be set at the full external damage cost rather than the current market price, where this exists, to incentivise anticipatory action.

This approach could also be extended to other institutions, such as institutional investors, building on international progress on investor stewardship. The OECD[82] has stated that 'financial regulators and supervisors also have a role to play in encouraging long-term, active investment. They can support national or international codes of good practice (such as the Stewardship Code which is gaining widespread support in the UK) and issue guidance themselves of how they expect institutional investors to behave.' The OECD proposes that 'in order to nudge investors to follow such guidance, supervisors can shift the focus on their investigations, enquiring as to the turnover of funds, the length of mandates given to external managers, how fees are structured, voting behaviour etc.'

It argues that if supervisors believe that investors may be acting in too short-term a manner, they could increase their oversight of the institution. Such actions could help address the agency problem, making institutional investors aware of their fiduciary duties and that they are the ultimate owners of the companies in which they invest, with the consequent responsibilities this entails. Supervisory authorities could also help to foster a focus on longer-term performance by releasing or requiring comparative data on returns over longer time periods.[83]

3.1.3 Evaluating systemic risk implications

[78] Cunado and Ferreira, 2014.
[79] Masson, 2014.
[80] Ibid.
[81] See Kapoor et al., 2011.
[82] Della Croce, Stewart and Yermo, 2011.
[83] Ibid.

The systemic risk potentially associated with carbon exposure and 'unburnable carbon' has recently been raised with regulators, particularly in the UK. In January 2012 a group of investors began a high-profile correspondence with the Financial Policy Committee of the Bank of England by urging it, 'to investigate how Britain's exposure to polluting and environmentally damaging investments might pose a systemic risk to the UK financial system and prospects for long term economic growth.'[84] The then bank governor, Sir Mervyn King, recognised in a response from February 2012 that there, 'is clearly scope for further evaluation of these issues, in particular the potential scale of the risk and transmission mechanisms through which it might impact UK financial stability.'[85] He then set out three conditions that would need to be met for this to be considered a systemic risk by the Bank: 1) that exposure to carbon-intensive sectors is large relative to overall assets, 2) that the policies and technologies working to reduce returns in high carbon areas are not already priced by the market, and 3) that any subsequent correction would not give sufficient time for financial institutions to adjust their portfolios in an orderly manner.[86]

The Environmental Audit Committee of the House of Commons in a February 2014 report, and then in a July 2014 letter, also subsequently recommended that the, 'Financial Policy Committee of the Bank of England should regularly consult with the Committee on Climate Change to help it monitor the risks to financial stability associated with a carbon bubble.'[87] The Greens/European Free Alliance, a political grouping within the European Parliament, also published research in February 2014 estimating that the exposure of EU financial institutions to at risk fossil fuel assets was €1trn and that under a 'shock' scenario losses could amount to €350-400bn, enough to merit a systemic risk to the EU financial system.[88]

Despite these developments, future macro-prudential regulations remain an uncertainty with respect to stranded assets. Currently it is unclear how environment-related risks may be explicitly addressed (if at all) in such regulations, but analysts have suggested that a potential 'Basel IV' could result in 'tougher requirements on the leverage ratio, risk-weighted assets and stress testing'.[89] But given that environment-related risks are likely to affect underlying asset bases of banks (to the degree that they lend to clients in environmentally vulnerable/high risk industries) there may be implications for asset risk weighting, potentially leading to higher capital requirements for assets with greater levels of exposure to such risks.

3.1.4 Other policy responses

There are a range of policy drivers (including conservation, trade, industrial, and social policies) that have the potential to increasingly affect the relationship between environment-related risk and the financial sector.

i) Policies to conserve/sustain natural capital, including investment

It is becoming increasingly accepted that well-designed policies to support natural capital resilience and conservation are considered positive for long-run economic competitiveness, as they help to drive resource productivity.[90] Regulatory and legislative responses to mitigate, abate, or manage natural capital degradation and other environment-related risks comprise a significant body of response measures, including:

- Conservation policy
- Protected areas and knock-on effects
- Investments in ecosystem restoration and rehabilitation
- Investments in natural infrastructure

84 Abberley et al., 2012.
85 King, 2012.
86 Environmental Audit Committee, 2014a.
87 Environmental Audit Committee (2014b).
88 Weyzig et al., 2014.
89 KPMG, 2014.
90 HSBC, 2014.

- Investments in ecosystem resilience

ii) Trade policies, industrial policies, and social policies

Impacts on financial stability may arise from national-level regulations and policies that affect business competitiveness and trade. The most important of such actions include production restrictions, import restrictions, and export restrictions implemented to control, abate, or maintain natural capital (such as key environmental resources). As these policies may often be directly designed to affect trade flows, they may have ripple effects across the economy that pose sector-wide or potentially systemic financial risks.

Finally, policies in response to significant social or civil society concern could also have financial implications. Examples of this can be seen in the recent campaign to divest from fossil fuels in the US and the EU,[91] as well as public protest in response to air pollution in China. As social norms around natural capital may change rapidly if human health and human environmental quality are negatively affected, governments are likely to respond rapidly (and potentially unpredictably) to social issues with policies that may significantly affect financial markets.

3.2 Finance sector

3.2.1 Stress testing, disclosure, and integrated reporting

Financial stakeholders are implementing a range of responses to environment-related risks, but most fall into what can be understood as very preliminary risk assessments. A standard progression of 'assessment/transparency/management' can be seen in the responses of financial stakeholders, with many only taking initial steps towards proactively managing environment-related risks. Key mechanisms in this space include stress testing, risk analysis, risk disclosure, and integrated reporting. A significant number of new industry bodies providing guidance in this area have been established, including standards boards, councils, and various coalitions between industry, regulators, and international organisations. While it is beyond the scope of this paper to review each of these in detail, we can make a number of general observations:

- Established financial sector standard-setters (such as IASB and FASB) are taking steps towards requiring greater transparency of environmental footprints in general, as well as specific actions on water, biodiversity, and other natural capital risks. In addition, these standards are implementing actions to assess various climate-related exposures, including carbon footprint accountability/exposure, and exposure to sea level rise.
- The wide range of standards and guidance bodies (including the GRI, WBCSD, SASB, CDSB, ISAR, CDP, AODP, and others) have begun to implement new frameworks to improve the rigour and utility of sustainability, climate, and natural capital disclosure outputs. Some of these bodies have also targeted new financial stakeholders in the investment chain, including asset owners.[92]
- According to Ceres (2014), investor demand for mandatory environmental and social disclosure is pushing ESG reporting into the mainstream. Seventeen countries already require some form of corporate sustainability disclosure, and there is increasing support for similar requirements in the United States.
- Recent developments in established reporting systems and channels (such as climate risk within the SEC) suggest that uptake is a potentially long and slow process, which has little impact in the short run.[93]
- Beyond specific firms or financial stakeholder groups actions on natural capital may be implemented through exchanges, as illustrated by the preliminary progress towards carbon reporting requirements

[91] Ansar et al., 2013.
[92] AODP, 2013.
[93] Ceres, 2014.

for stock exchanges. Some of the recent work in this area is being coordinated by the UN's Sustainable Stock Exchange Initiative.[94]

- An ongoing letter campaign organized by the Principles for Responsible Investment (PRI), Ceres, and the UNEP-Finance Initiative (UNEP-FI) requests that IOSCO work closely with regulators, stock exchanges, and other related parties to improve the disclosure of ESG information in the global marketplace. The campaign suggests that IOSCO take action in a variety of ways in order to bring about more consistent disclosure rules, develop accountability mechanisms, and help issuers and capital market influencers better understand the benefits of ESG disclosure.

3.2.2 Securitisation of environment-related risks

Many insurers, reinsurers, and other financial stakeholders are undertaking efforts to reduce environment-related risk exposure through the issuance of financial securities. The use of catastrophe bonds ('cat bonds') and other insurance-linked securities (ILS) are becoming increasingly prevalent in transferring environment-related risks and potential stranded assets to capital markets, often via indexed approaches to valuing damages from NCEs. Cat bonds are a private sector mechanism that are related to a wider group of public and private disaster risk financing mechanisms, which are outlined in Figure 2. The IPCC's recent AR5 WG2 report supports catastrophe bonds and risk securitisation as a key tool for the diversification of climate-related disaster risk across capital markets. New instruments that may operate as capital market risk transfer mechanisms include weather derivatives and hybrid products linking parametric climate-based and capital market loss triggers, acting as a hedge against a 'double hit' from direct disaster losses and losses incurred within asset management portfolios and capital markets.[95] Changes in the dynamics of these markets call attention to the potential for systemic risks arising across the financial system in response to increased exposure to NCE damages and stranded assets.

Figure 2: Non-traditional disaster risk financing mechanisms

Mechanism	Financing issue	Description	Stakeholders	Example
Catastrophe bonds	Need for insurers to transfer catastrophe-related underwriting risk to capital markets in order to de-risk portfolios	ILS (often fully collateralised) whereby investor receives return premium when specified NCE (often measured via indices) does not occur; when NCEs occur investors sacrifice interest premium	Private insurers and reinsurers, institutional investors	Wide range of catastrophe bond issuances[96]
National insurance programmes/pools	Reluctance of private insurers to offer insurance for high-risk and high cost NCEs, due to covariant dynamics affecting solvency	Insurance pool based on mandatory private capital contributions designed to reduce public fiscal exposure to disaster events; often guaranteed by government/donors	National governments	Turkish Catastrophe Insurance Pool [97]
Contingent credit	Inability to secure access to credit at appropriate rates in period of fiscal illiquidity following disaster events	Credit access agreement whereby governments pay a premium for a call option on a guaranteed loan at a predetermined rate, contingent on a disaster or some other defined event occurring	National governments, IFIs, MDBs	Colombia contingent credit agreement with the World Bank [98]
International insurance pools	Regional standards for disaster risk insurance pricing may be subject to fluctuations that effectively de-link premiums with recorded damages	International insurance risk sharing facility which allows governments to pay into a pool in order to access immediate liquidity at a lower cost than private insurance within capital markets	National governments	Caribbean Catastrophe Risk Insurance Facility; Pacific Catastrophe Risk Assessment Financing Initiative

[94] SSE, 2014.
[95] IPCC, 2014, Chapter 10.
[96] Artemis, 2014.
[97] Gurenko, 2004.
[98] Cummins and Mahul, 2008.

Alternative mechanisms	Various	Index-based micro-insurance	Various	Various
		Public sector risk transfer		
		Insurance of international donors		

Source: Adapted from Linnerooth-Bayer and Hochrainer-Stigler (2014)

4. Implications for China

China's strategic decision to move away from a high pollution and high resource intensive economy and build an 'eco-civilisation' will clearly have implications both for existing assets, as well as the trajectory of future capital investment. Shifts already well underway in China are a serious concern over air pollution, a desire to reduce greenhouse gas emissions, and to reduce exposure to volatile international commodity markets. This has resulted in the massive deployment of non-fossil energy driven by new policy frameworks, falling technology costs, and the emergence of carbon pricing, which are trends set to continue and grow. Increasing water scarcity could also adversely impact polluting sectors, while domestic shale gas and changing international gas markets will result in more coal to gas switching.

These and related changes, while problematic for some firms and sectors, need not hinder China's economic development and could actually work to support China's multiple, inter-locking objectives of addressing inequality, ensuring sustainable growth, increasing domestic consumption, and improving social infrastructure.

One opportunity is to secure an optimal rate of asset stranding given China's level of economic development, targeted rate of economic growth, and sustainability concerns. Too little asset turnover could leave China with insufficiently productive assets far from technological frontiers, while too much could result in unmanageable losses for companies and financial institutions, as well as challenging social issues due to job losses and displaced industries. While leaving polluting, inefficient assets in place will undermine sustainability and long-term growth.

Another dimension related to securing an optimal rate of asset stranding is the avoidance of lock-in. China should avoid investing in technologies and infrastructure that might quickly become outdated or inappropriate from a societal perspective.[99] An example could be new build sub-critical coal-fired power stations given ever-increasing concerns over air pollution and water scarcity, as well as the availability of cost competitive alternatives. Lock-in of this kind is expensive for society as a whole and ties up capital that could be deployed productively elsewhere.

The profile of a transition pathway is also important. The value lost through asset stranding should ideally be more than offset by new value creation in other areas and this should happen smoothly over time. This is preferable to a transition that is staggered or 'lumpy' and one where value destruction overwhelms value creation, even if only temporarily. Without a smooth and gradual profile, it will be harder to secure political and societal support. An analysis of stranded assets can help to reveal the potential profile of a transition pathway and additionally, help to identify winners and losers across sectors. Identifying the groups affected, particularly those negatively impacted, can allow for the provision of targeted transitional help – another way of ensuring support is sustained throughout a transition that might involve painful losses for some firms.

In terms of the financial system, better understanding the materiality of environment-related risks and the levels of exposure in different parts of the financial system will help regulators manage scenarios that could result in financial instability. Within financial institutions, revealing and better pricing environment-related risks will improve risk management and hedging, potentially improving system resilience as well as portfolio performance. Higher risk premia for assets more exposed to environment-related risks may also have the added benefit of shifting capital allocations away from sectors that could be considered environmentally unsustainable, and towards assets more in-line with China's vision for a cleaner and more sustainable economy.

In addition to the implications for financial markets, environment-related risks and stranded assets will impact company strategy. Companies exposed to environment-related risk factors or dependent on clients exposed to

[99] The corollary of this is that in some cases it might be better to 'sweat' existing assets until viable long-term replacements can be found. In other words, instead of investing in an intermediate option that may need to be replaced relatively quickly, it could be better to defer investment.

these risks may need to adapt their business models. Exporters, particularly those exposed to environmental regulation in key export markets, could be particularly vulnerable. Those dependent on imported resources which could be affected by more price volatility in international commodity markets due to environmental change, might also be at risk. Firms better able to manage emerging environment-related risks could also secure significant competitive advantages over time.

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